US008594850B1

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Gourlay et al.

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(54) **UPDATING CONTROL SOFTWARE ON A NETWORK-CONNECTED HVAC CONTROLLER**

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(73) Assignee: **Nest Labs, Inc.**, Palo Alto, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **13/632,133**

(22) Filed: **Sep. 30, 2012**

(51) **Int. Cl.**

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G05B 13/00	(2006.01)
G05B 15/00	(2006.01)
G05B 23/00	(2006.01)
G06F 9/44	(2006.01)
B60H 1/00	(2006.01)
F22B 3/00	(2006.01)

(52) **U.S. Cl.**
USPC ..... **700/276**; 700/277; 700/278; 700/299; 700/300; 236/1 B; 236/1 E; 236/3; 236/101 C; 717/168; 717/171; 717/173; 717/174; 707/638; 707/695; 165/11.1; 165/11.2; 165/203; 165/270

(58) **Field of Classification Search**
USPC ..... 700/276–278, 299–300; 236/1 B, 1 E, 3, 236/101 C; 165/11.1–11.2, 200, 203, 270; 717/122, 168, 170–174, 177–178; 707/638, 695, 806; 715/229
See application file for complete search history.

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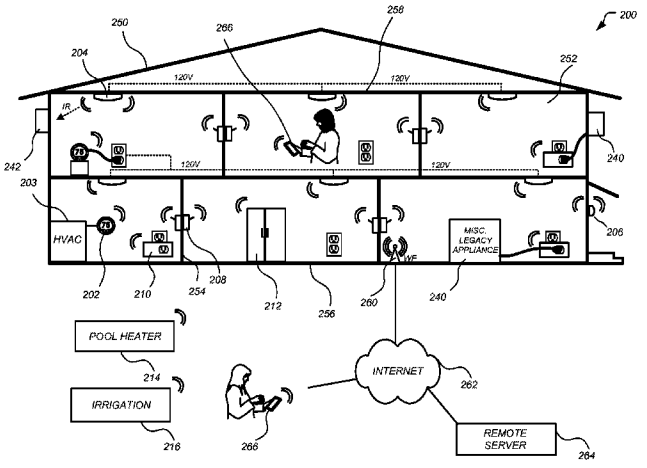
Primary Examiner — Ramesh Patel
(74) *Attorney, Agent, or Firm* — Kilpatrick Townsend & Stockton LLP

(57) **ABSTRACT**

Apparatus, systems, methods, and computer program products are disclosed for providing software updates to client devices. A client device (such as a thermostat) executes software to perform one or more functionalities of the device. Upon receiving an indicating that a software update is available, the device waits to download the software update until pre-download conditions are satisfied. Once the software update is downloaded, the device then waits to install the software update until pre-install conditions are satisfied. If the software update is non-critical and received during an initial installation of the device, the software update may not be installed until after installation of the device is complete. If the device is a thermostat, the device may delay installation of the software update until a controlled HVAC system in inactive. Control of the HVAC system may be disabled during installation of the software update.

30 Claims, 15 Drawing Sheets



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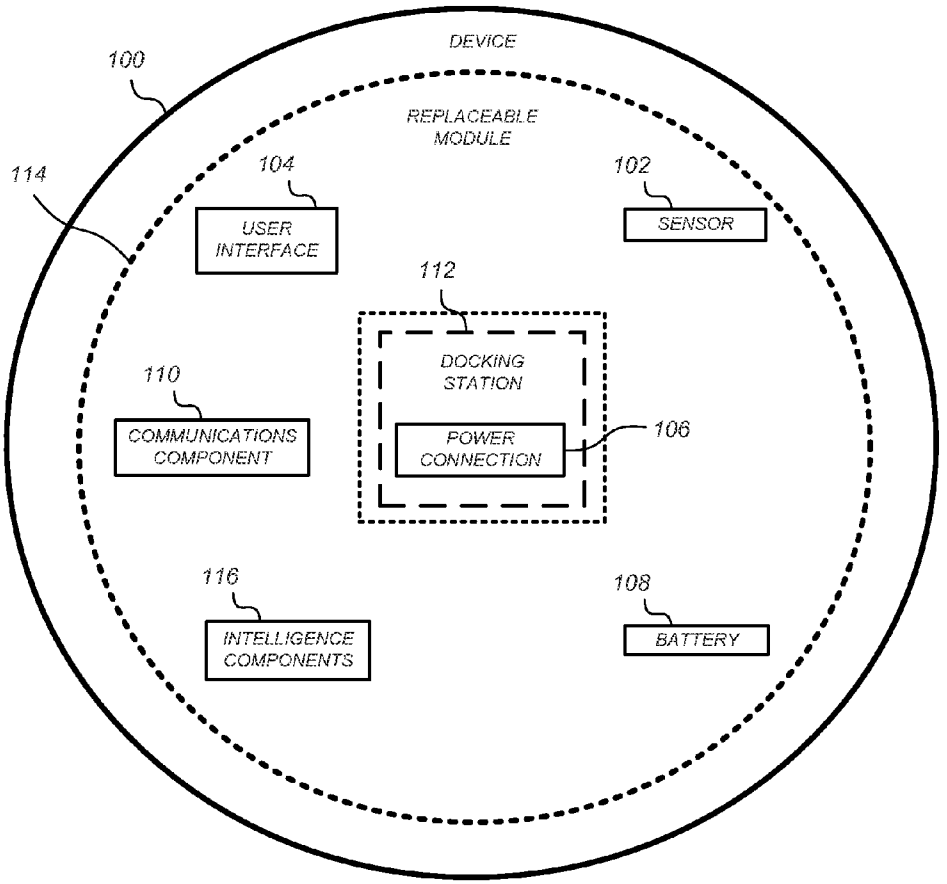
DEVICE
100
REPLACEABLE MODULE
114
104
USER INTERFACE
102
SENSOR
112
DOCKING STATION
110
COMMUNICATIONS COMPONENT
POWER CONNECTION
106
116
INTELLIGENCE COMPONENTS
108
BATTERY

FIG. 1A

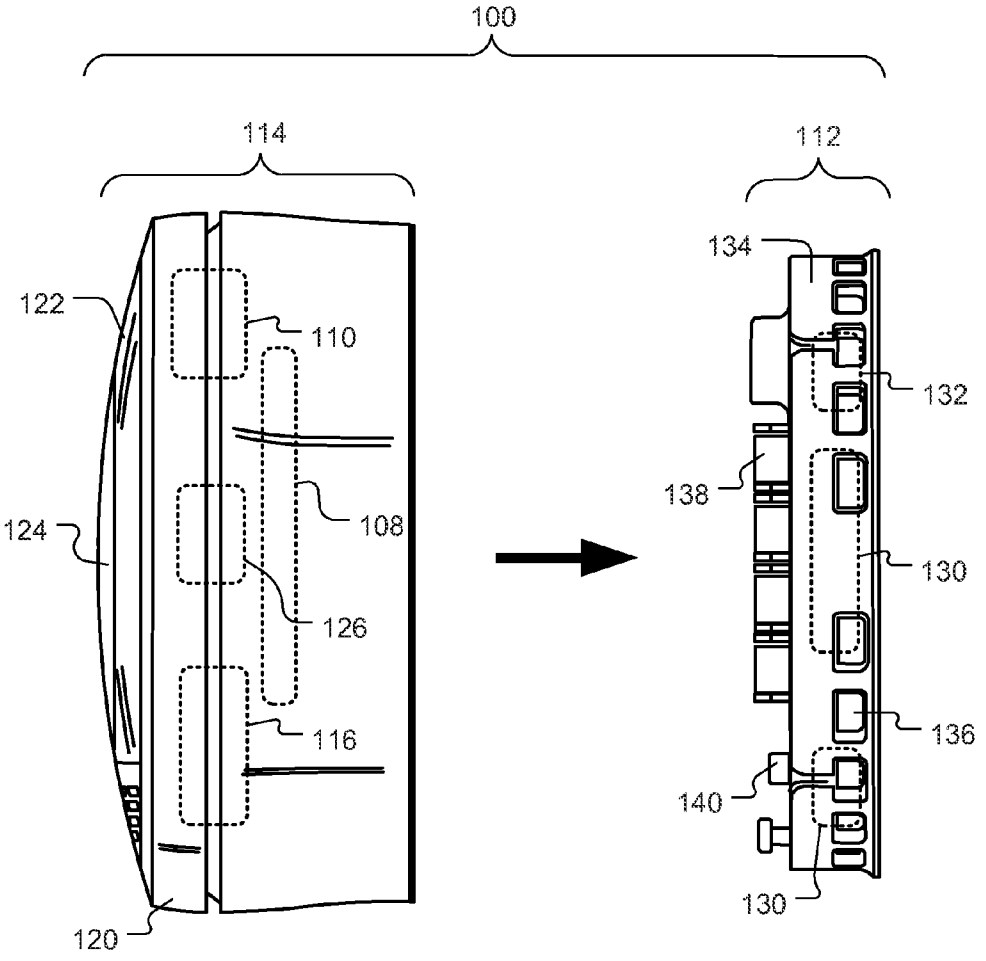
100
114
112
122
110
134
132
138
108
124
130
126
116
136
140
130
120

FIG. 1B

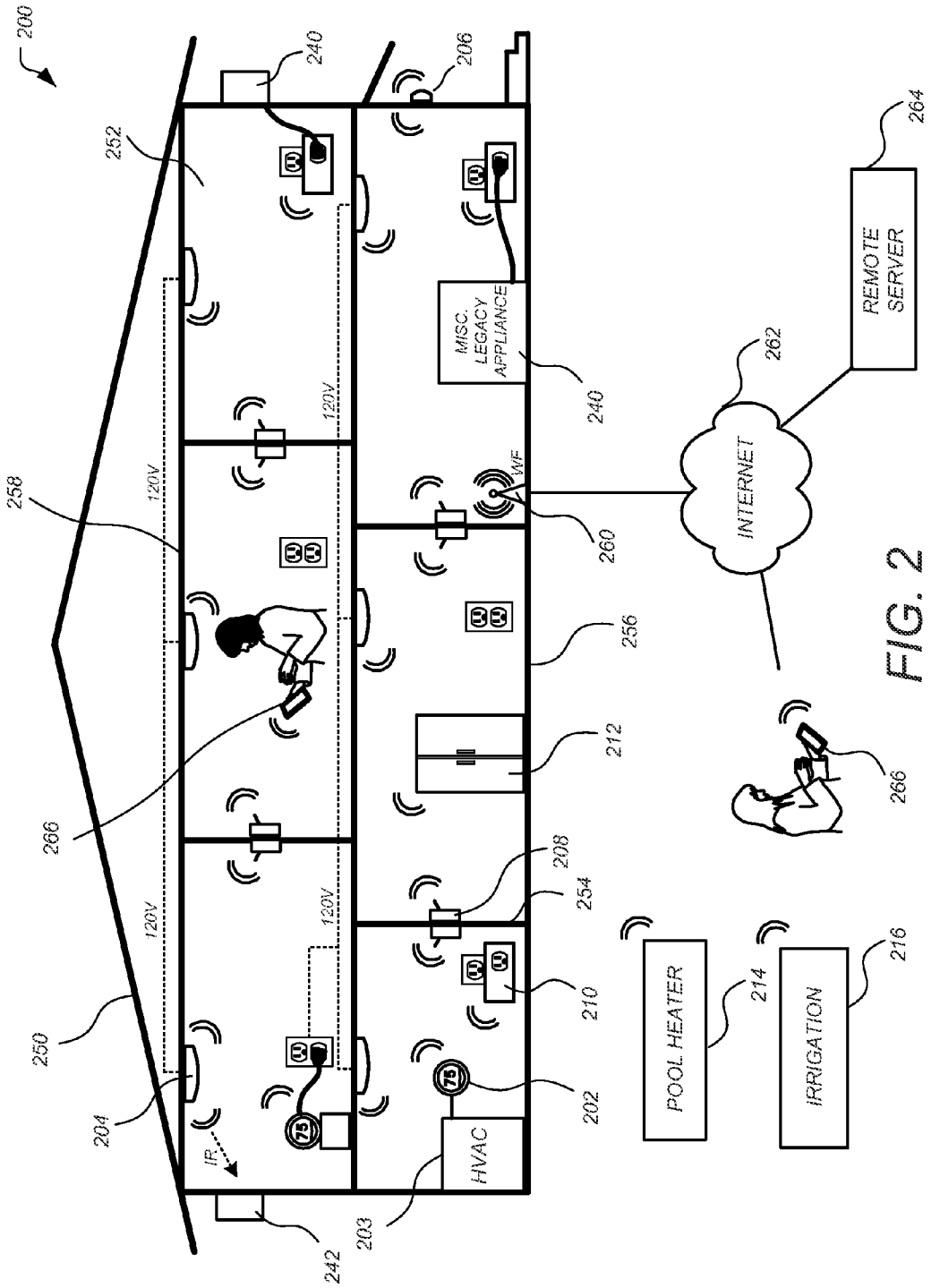
200
240
206
252
120V
258
MISC. LEGACY APPLIANCE
240
WF
260
INTERNET
262
REMOTE SERVER
264
256
212
266
208
254
210
250
204
202
POOL HEATER
214
IRRIGATION
216
IR
HVAC
203
242

FIG. 2

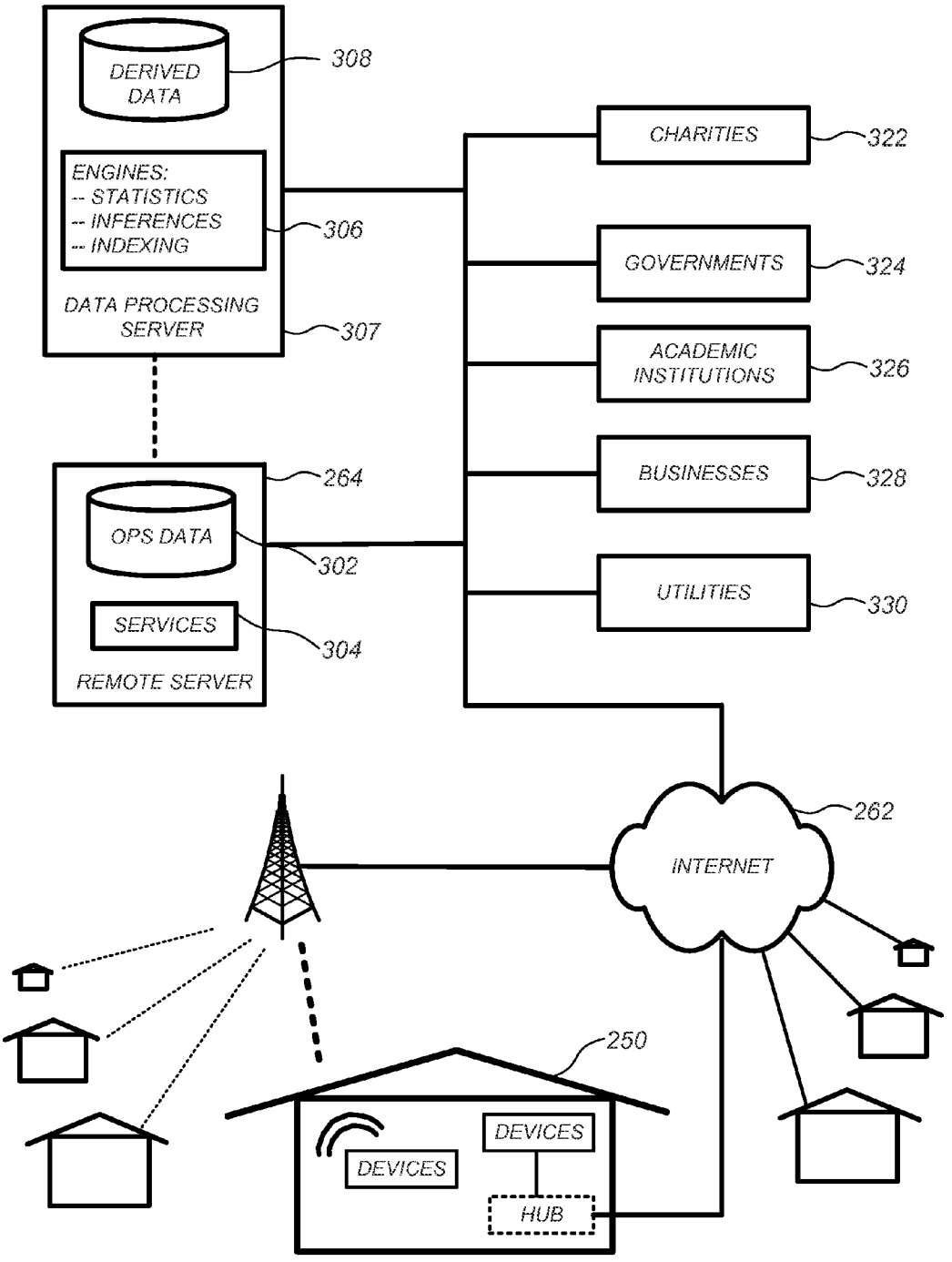
DERIVED DATA
308
ENGINES:
-- STATISTICS
-- INFERENCES
-- INDEXING
306
DATA PROCESSING SERVER
307
264
OPS DATA
302
SERVICES
304
REMOTE SERVER
CHARITIES
322
GOVERNMENTS
324
ACADEMIC INSTITUTIONS
326
BUSINESSES
328
UTILITIES
330
262
INTERNET
250
DEVICES
DEVICES
HUB

FIG. 3

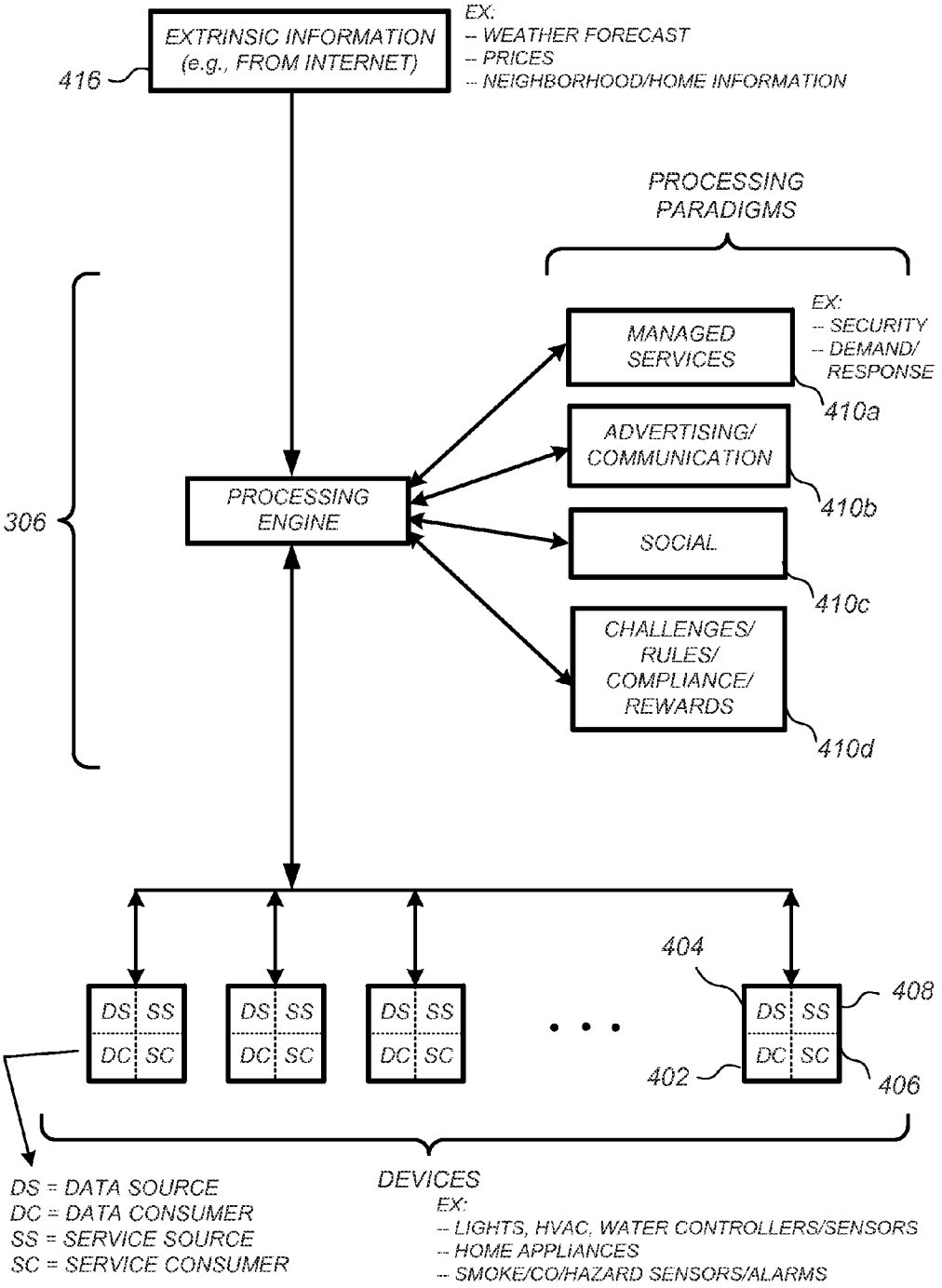
EXTRINSIC INFORMATION (e.g., FROM INTERNET)
416
EX:
-- WEATHER FORECAST
-- PRICES
-- NEIGHBORHOOD/HOME INFORMATION
PROCESSING PARADIGMS
306
PROCESSING ENGINE
MANAGED SERVICES
EX:
-- SECURITY
-- DEMAND/ RESPONSE
410a
ADVERTISING/ COMMUNICATION
410b
SOCIAL
410c
CHALLENGES/ RULES/ COMPLIANCE/ REWARDS
410d
404
408
402
406
DS SS
DC SC
DS = DATA SOURCE
DC = DATA CONSUMER
SS = SERVICE SOURCE
SC = SERVICE CONSUMER
DEVICES
EX:
-- LIGHTS, HVAC, WATER CONTROLLERS/SENSORS
-- HOME APPLIANCES
-- SMOKE/CO/HAZARD SENSORS/ALARMS

FIG. 4

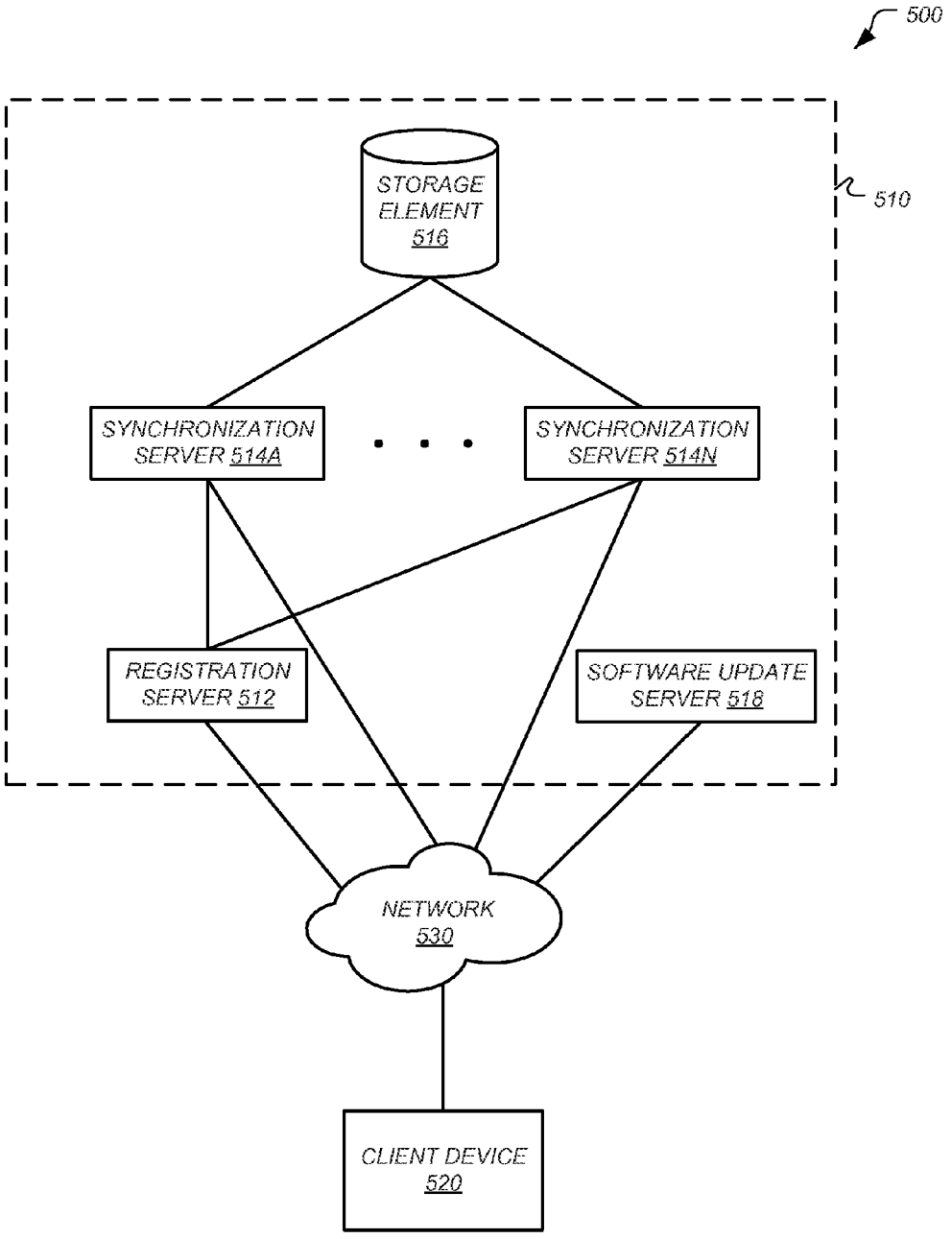
500
510
STORAGE ELEMENT 516
SYNCHRONIZATION SERVER 514A
SYNCHRONIZATION SERVER 514N
REGISTRATION SERVER 512
SOFTWARE UPDATE SERVER 518
NETWORK 530
CLIENT DEVICE 520

FIG. 5

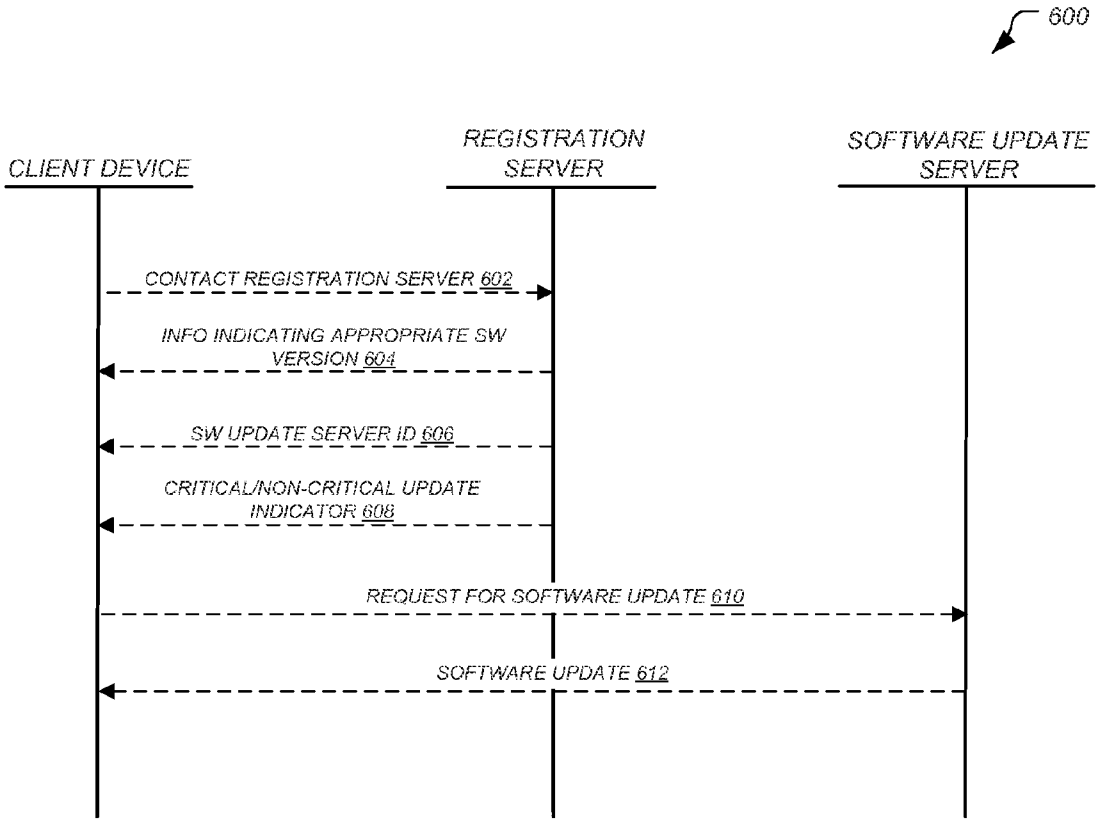
600
CLIENT DEVICE
REGISTRATION SERVER
SOFTWARE UPDATE SERVER
CONTACT REGISTRATION SERVER 602
INFO INDICATING APPROPRIATE SW VERSION 604
SW UPDATE SERVER ID 606
CRITICAL/NON-CRITICAL UPDATE INDICATOR 608
REQUEST FOR SOFTWARE UPDATE 610
SOFTWARE UPDATE 612

FIG. 6

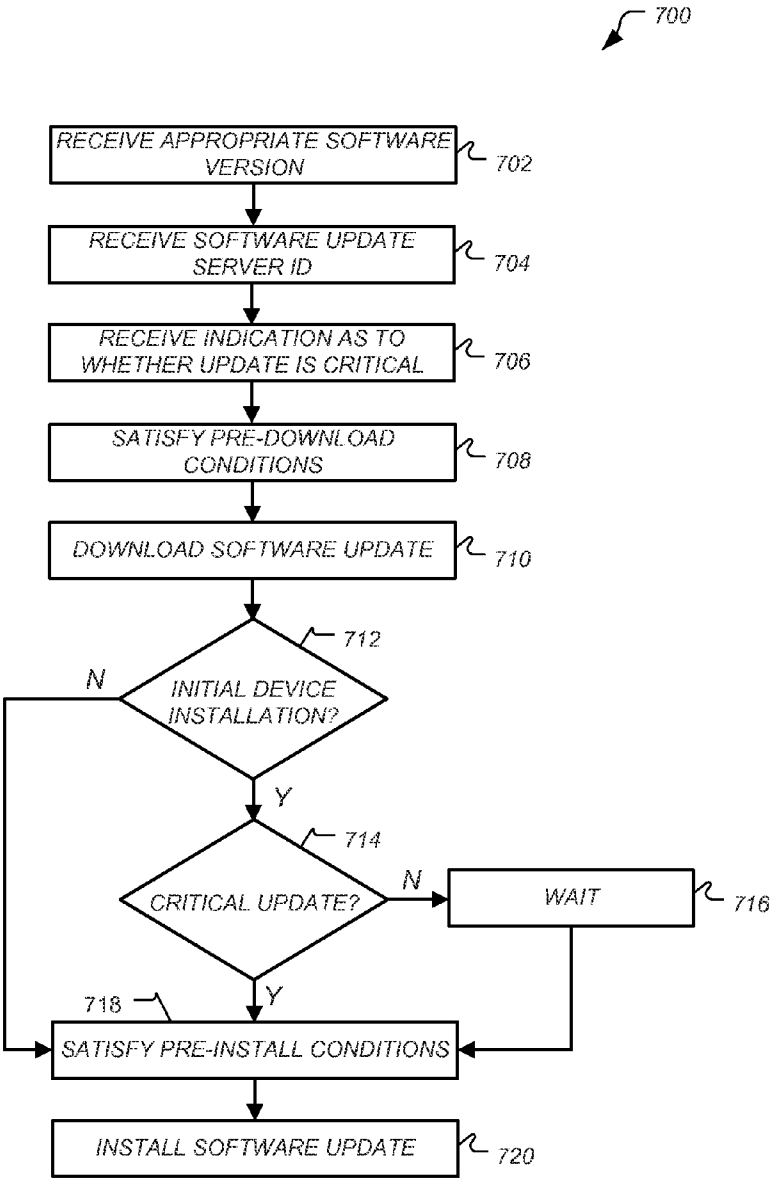
700
RECEIVE APPROPRIATE SOFTWARE VERSION
702
RECEIVE SOFTWARE UPDATE SERVER ID
704
RECEIVE INDICATION AS TO WHETHER UPDATE IS CRITICAL
706
SATISFY PRE-DOWNLOAD CONDITIONS
708
DOWNLOAD SOFTWARE UPDATE
710
712
INITIAL DEVICE INSTALLATION?
N
Y
714
CRITICAL UPDATE?
N
WAIT
716
Y
718
SATISFY PRE-INSTALL CONDITIONS
INSTALL SOFTWARE UPDATE
720

FIG. 7

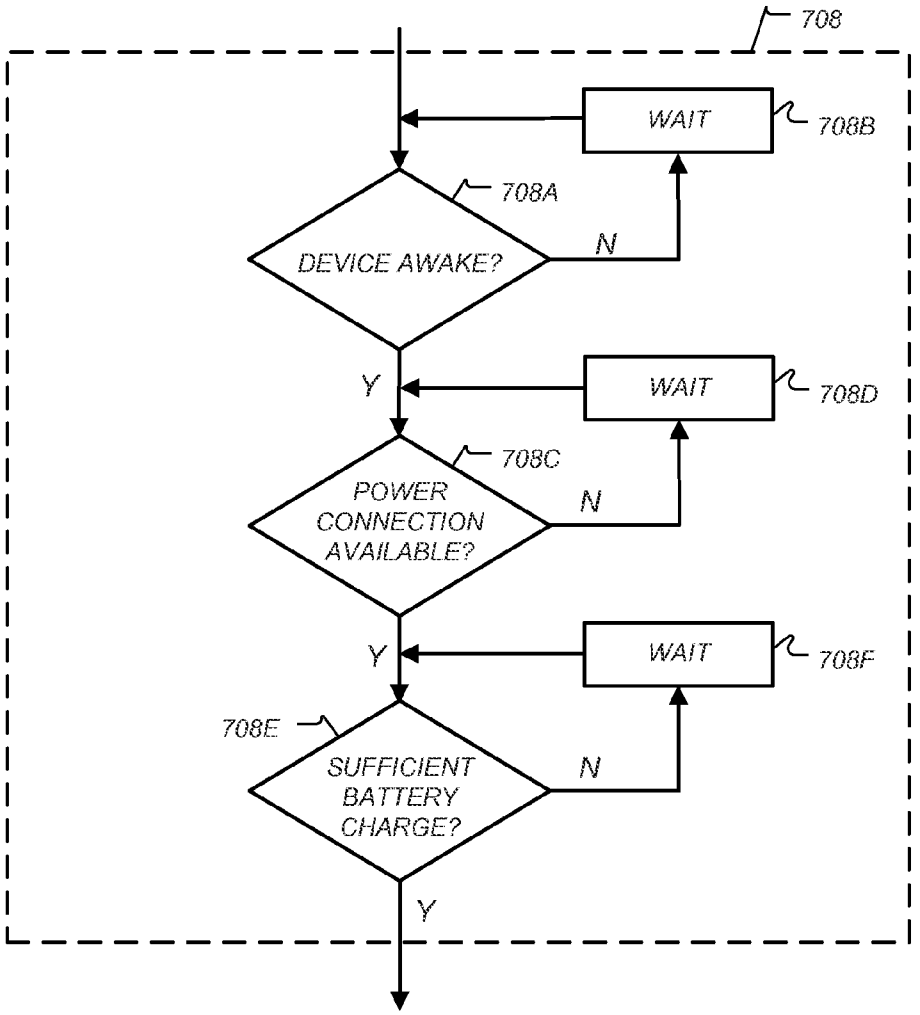
708
WAIT
708B
708A
DEVICE AWAKE?
N
Y
WAIT
708D
708C
POWER CONNECTION AVAILABLE?
N
Y
WAIT
708F
708E
SUFFICIENT BATTERY CHARGE?
N
Y

FIG. 8A

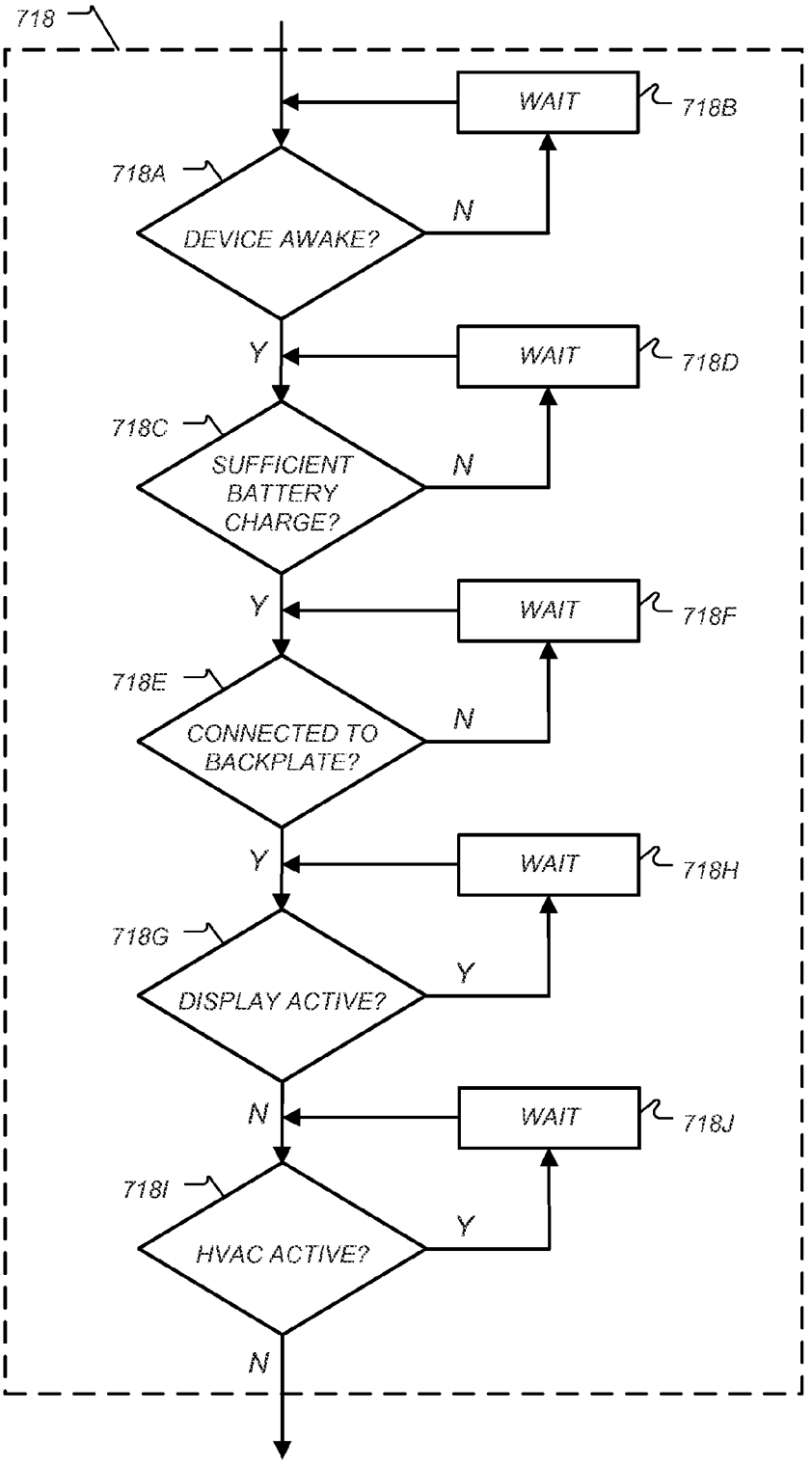
718
WAIT
718B
718A
DEVICE AWAKE?
N
Y
WAIT
718D
718C
SUFFICIENT BATTERY CHARGE?
N
Y
WAIT
718F
718E
CONNECTED TO BACKPLATE?
N
Y
WAIT
718H
718G
DISPLAY ACTIVE?
Y
N
WAIT
718J
718I
HVAC ACTIVE?
Y
N

FIG. 8B

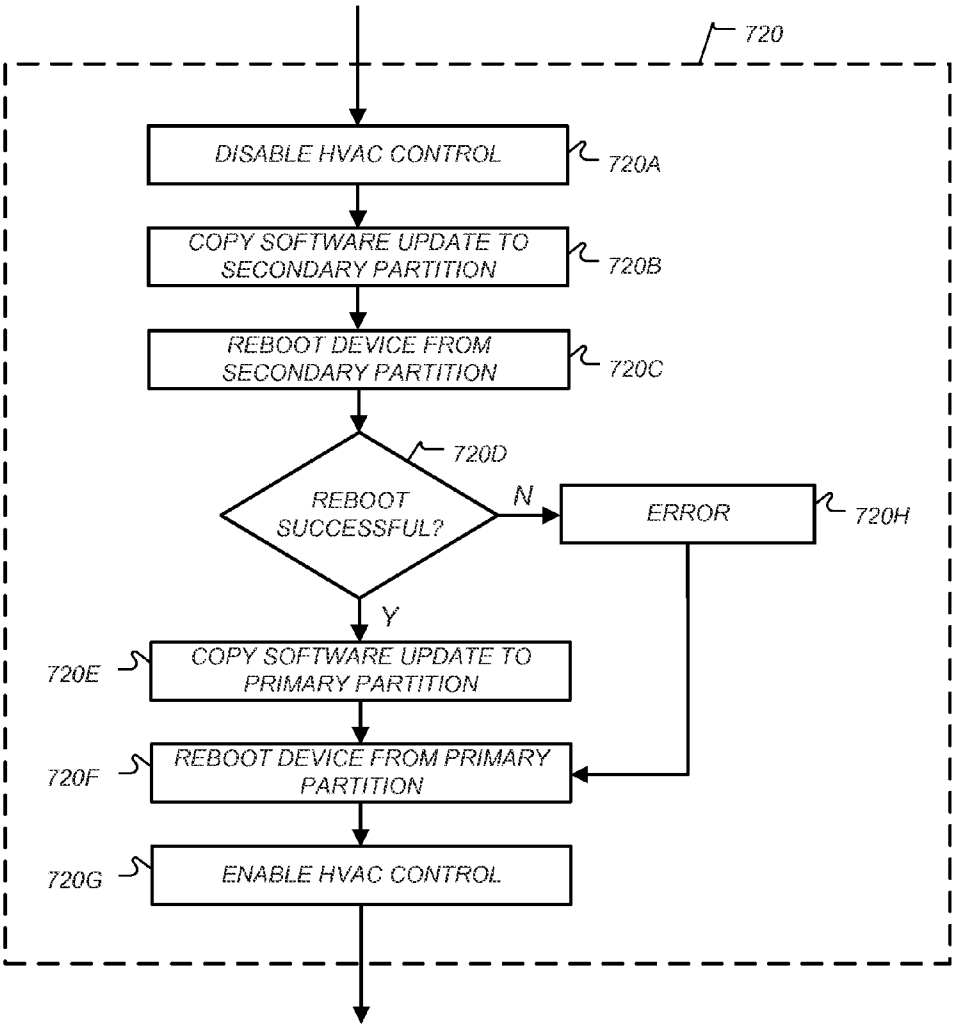
720
DISABLE HVAC CONTROL
720A
COPY SOFTWARE UPDATE TO SECONDARY PARTITION
720B
REBOOT DEVICE FROM SECONDARY PARTITION
720C
720D
REBOOT SUCCESSFUL?
N
ERROR
720H
Y
720E
COPY SOFTWARE UPDATE TO PRIMARY PARTITION
720F
REBOOT DEVICE FROM PRIMARY PARTITION
720G
ENABLE HVAC CONTROL

FIG. 8C

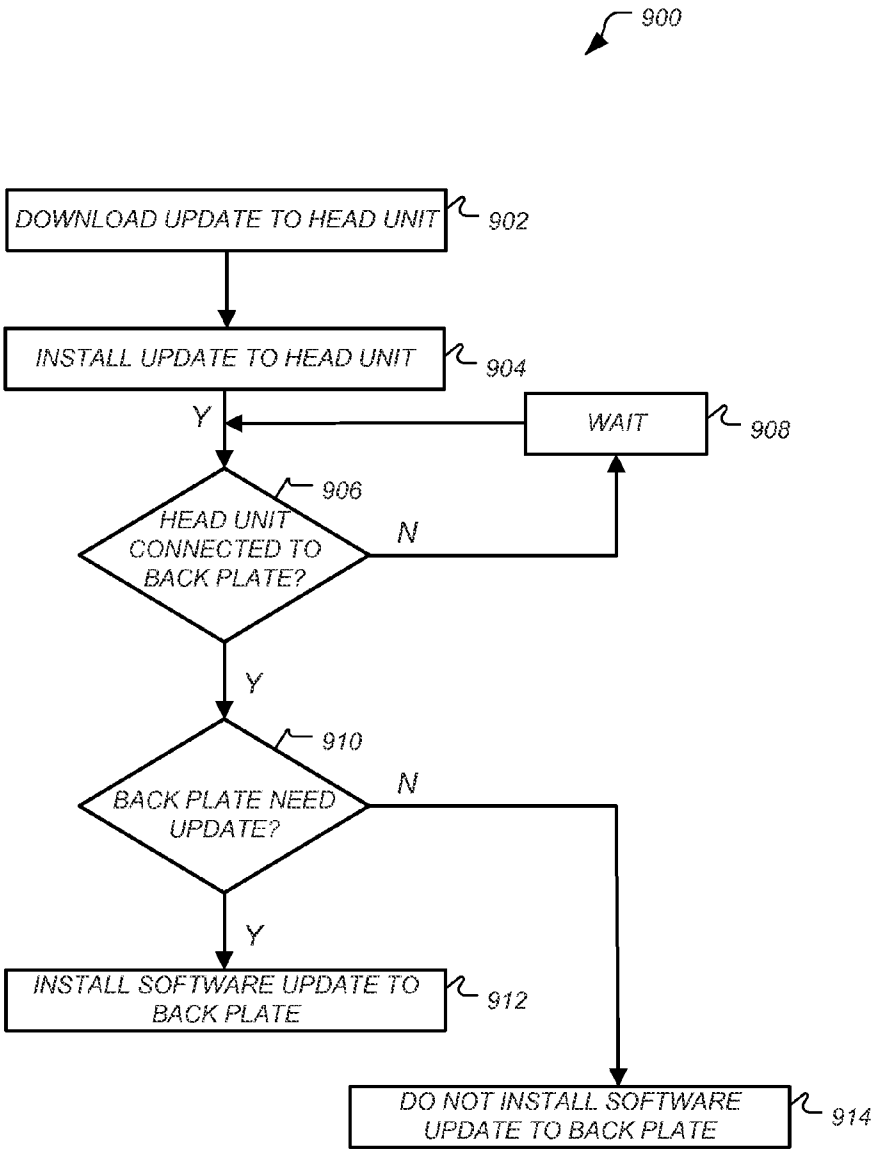
900
DOWNLOAD UPDATE TO HEAD UNIT
902
INSTALL UPDATE TO HEAD UNIT
904
Y
WAIT
908
906
HEAD UNIT CONNECTED TO BACK PLATE?
N
Y
910
BACK PLATE NEED UPDATE?
N
Y
INSTALL SOFTWARE UPDATE TO BACK PLATE
912
DO NOT INSTALL SOFTWARE UPDATE TO BACK PLATE
914

FIG. 9A

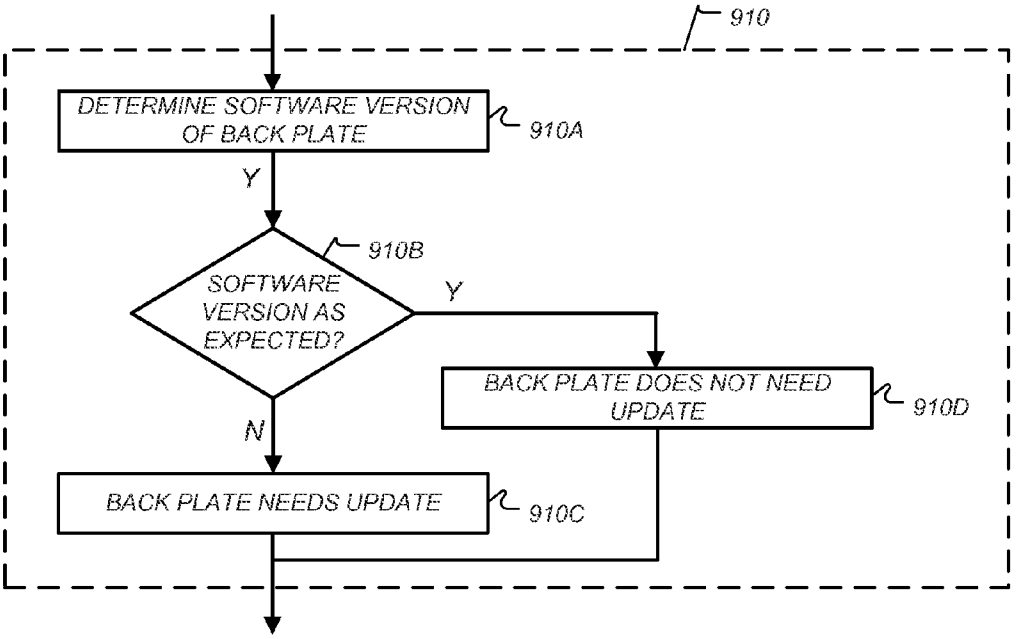
910
DETERMINE SOFTWARE VERSION OF BACK PLATE
910A
Y
910B
SOFTWARE VERSION AS EXPECTED?
Y
BACK PLATE DOES NOT NEED UPDATE
910D
N
BACK PLATE NEEDS UPDATE
910C

FIG. 9B

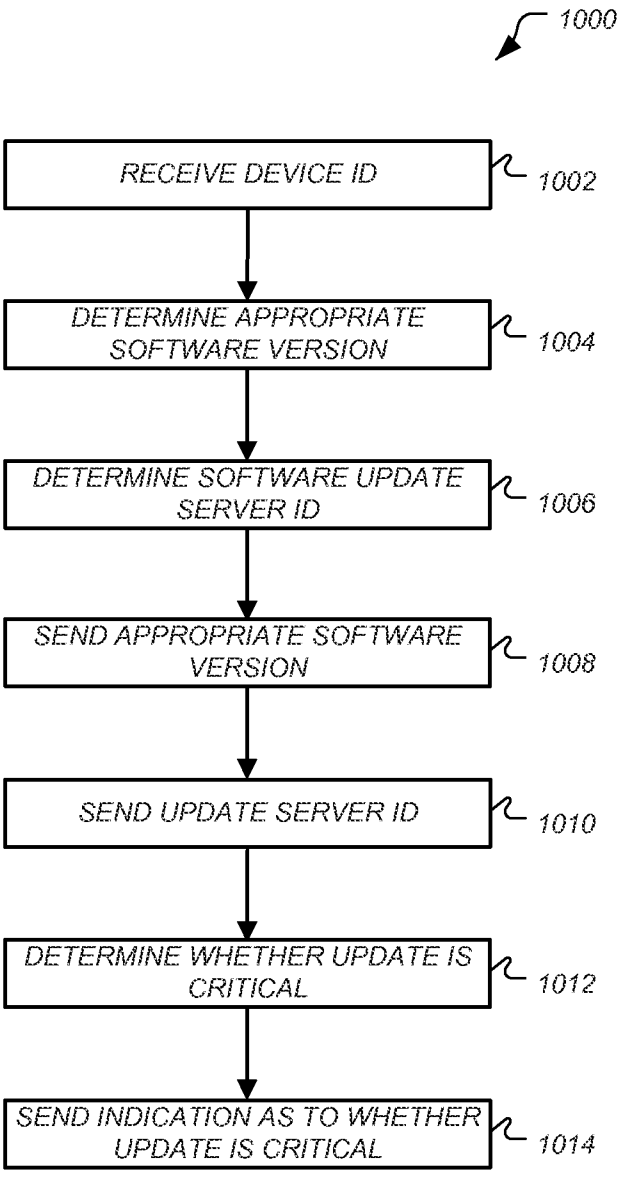
1000
RECEIVE DEVICE ID
1002
DETERMINE APPROPRIATE SOFTWARE VERSION
1004
DETERMINE SOFTWARE UPDATE SERVER ID
1006
SEND APPROPRIATE SOFTWARE VERSION
1008
SEND UPDATE SERVER ID
1010
DETERMINE WHETHER UPDATE IS CRITICAL
1012
SEND INDICATION AS TO WHETHER UPDATE IS CRITICAL
1014

FIG. 10

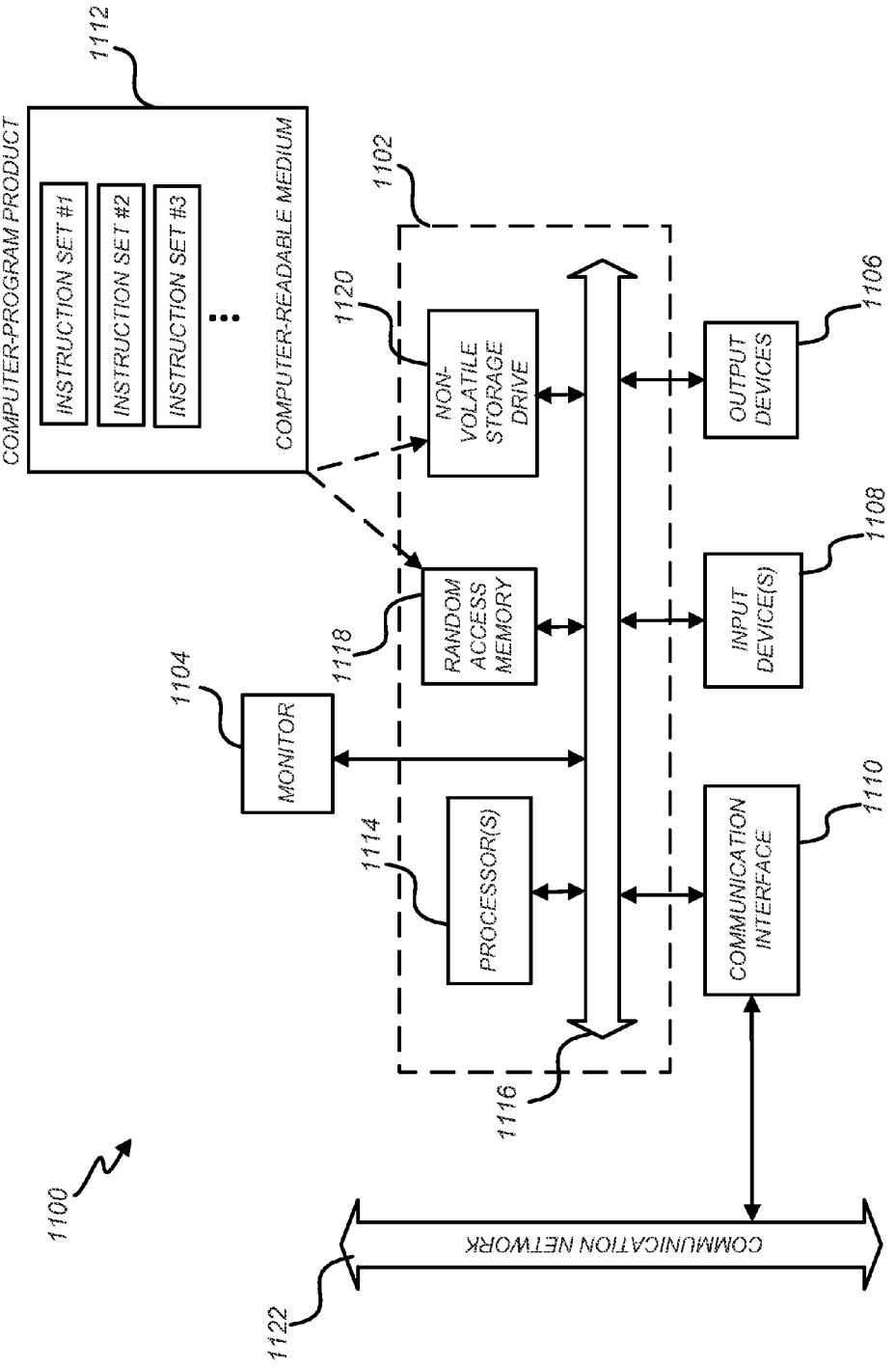
1112
COMPUTER-PROGRAM PRODUCT
INSTRUCTION SET #1
INSTRUCTION SET #2
INSTRUCTION SET #3
COMPUTER-READABLE MEDIUM
1102
1120
NON-VOLATILE STORAGE DRIVE
1106
OUTPUT DEVICES
1108
INPUT DEVICE(S)
1118
RANDOM ACCESS MEMORY
1104
MONITOR
1114
PROCESSOR(S)
1110
COMMUNICATION INTERFACE
1116
1100
COMMUNICATION NETWORK
1122

FIG. 11

UPDATING CONTROL SOFTWARE ON A NETWORK-CONNECTED HVAC CONTROLLER

FIELD

This patent specification relates to systems, methods, and related computer program products for performing software updates. More particularly, this patent specification relates to techniques for performing user-friendly software updates in potentially power-limited network-connected electronic devices.

BACKGROUND

Many, if not most, electronic devices in use today have installed thereon some type of software for facilitating operation of the electronic device. Such software may include operating systems, such as the Windows operating system by Microsoft Corp. of Redmond, Wash. Such software typically also includes application software that executes over the operating system and provides additional device functionality, such as the Office software also by Microsoft Corp. Incremental changes to such software (the operation system and/or application software) are often made by the software developers to provide improvements, address deficiencies, or for other reasons. These changes are commonly propagated to the user of the software over wired or wireless networks so that the user may revise their software with the latest software upgrades provided by the developers.

While certain mechanisms for updating software on an electronic device are currently available, substantial disadvantages can arise for certain known methods in that they tend to be a one-size-fits-all approach that does not take into account the nature of the device that is being updated in terms of the problems, pitfalls, inconveniences, and even dangers that can arise for that particular type of device. For example, many such known software updating mechanisms are typically implemented in environments whereby the electronic device is either constantly connected to a reliable power source (e.g., a desktop computer connected to an AC power source) or may easily be connected to a reliable power source via minimal user interaction (e.g., a user may plug a portable electronic device such as a smartphone into an AC power source). Modern day techniques, however, have yet to consider much less address environments whereby the electronic device has limited access to power and users may be significantly hindered in providing reliable access to power. Even though electronic devices may exist in such environments, like their power-satisfied cousins such devices may similarly derive various benefits from reliably receiving and installing software updates. While one or more of the embodiments described hereinbelow have been found to be particularly advantageous in the context of a network-connected thermostat designed to control an HVAC system, it is to be appreciated that the scope of the present teachings is not so limited, and can advantageously be applied across a broad array of smart-home devices in which one or more similar issues may be faced.

SUMMARY

Various techniques for providing software updates are disclosed herein. While such techniques may be implemented in various electronic devices across a variety of computing environments, some techniques may be particularly well-suited for environments where one or more of the electronic devices have relatively low power capacity and limited access to power sources. By way of example and not by way of limitation, thermostats provided in structured environments may have limited amounts of power capacity (e.g., a rechargeable lithium-ion battery) that is replenished using power stealing techniques that 'steal' or otherwise acquire power from HVAC systems which the thermostats are coupled to control. While these power stealing may advantageously replenish power stores as it is consumed by the thermostat, in some cases thermostats may, to provide superior functionality and user experience, consume power at a higher rate than that replenished. Further, in the particular example of thermostats installed in structured environments, a user typically cannot obviate the power limitations by simply 'plugging in' the device to a power source.

Updating software on electronic devices may spread the spectrum of complexity from a trivial to daunting. At one end of the spectrum, a software update may comprise almost superficial changes to a single software application or process executing or executable on the electronic device. At the other end of the spectrum, a software update may comprise replacement of an entire operating system of the electronic device. Regardless of the situation, however, common elements to a reliable update process exist, including the electronic device downloading or otherwise acquiring the software update, and installing the software update.

Techniques for reliably downloading and installing software updates in power limited environments are described herein. In one particular embodiment, an intelligent network-connected thermostat for controlling the operation of an HVAC system in a smart home environment is disclosed. Thermostat includes a communications component for communicating with at least one server that is located remotely from the thermostat, HVAC control circuitry operable to actuate one or more elements of the HVAC system, a storage element for storing computer software operable to control one or more functions of the thermostat, and a processor. The processor is operable to perform a variety of operations. For example, the processor may be operable to receive a criticality indicator indicating whether a software update to the computer software stored in the storage element is critical or not, download the software update from a software update server via the communications component, determine whether the software update was downloaded during an initial installation of the thermostat in a physical structure, determine, based on the criticality indicator, whether the software update is critical, and delay installation of the software update when it is determined that the software update is not critical and the software update was downloaded during the initial installation of the thermostat in the physical structure.

In another particular embodiment, a thermostat includes a communications component for communicating with at least one server that is located remotely from the thermostat, HVAC control circuitry operable to actuate one or more elements of the HVAC system, a storage element for storing computer software operable to control one or more functions of the thermostat, and a processor operable to perform a variety of operations. For example, the processor may be operable to download a software update to the computer software stored in the storage element from a software update server via the communications component, determine whether the HVAC control circuitry has actuated one or more elements of the HVAC system to be in an active state, and when it is determined that one or more elements of the HVAC system are in an active state, delay installation of the software update until the one or more elements of the HVAC system are in an inactive state.

In yet another particular embodiment, a thermostat includes a communications component for communicating with at least one server that is located remotely from the thermostat, HVAC control circuitry operable to actuate one or more elements of the HVAC system, a storage element for storing computer software operable to control one or more functions of the thermostat, and a processor operable to perform a variety of operations. For example, the processor may be operable to download a software update to the computer software stored in the storage element from a software update server via the communications component, disable control of one or more elements of the HVAC system, install the software update, and enable control of one or more elements of the HVAC system after installing the software update.

For a more complete understanding of the nature and advantages of embodiments of the present invention, reference should be made to the ensuing detailed description and accompanying drawings. Other aspects, objects and advantages of the invention will be apparent from the drawings and detailed description that follows. However, the scope of the invention will be fully apparent from the recitations of the claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A illustrates an example of general device components which can be included in an intelligent, network-connected device.

FIG. **1**B illustrates an intelligent, network-connected device having a replaceable module and a docking station according to some embodiments.

FIG. **2** illustrates an example of a smart home environment within which one or more of the devices, methods, systems, services, and/or computer program products described further herein can be applicable.

FIG. **3** illustrates a network-level view of an extensible devices and services platform with which a smart home environment can be integrated.

FIG. **4** illustrates an abstracted functional view of the extensible devices and services platform of FIG. **3**.

FIG. **5** depicts a system that implements techniques for updating software on a client device according to an embodiment.

FIG. **6** illustrates a communication sequence of a process for performing software updates according to an embodiment.

FIG. **7** is a flowchart of a process for a client device to perform software updating according to an embodiment.

FIG. **8**A is a flowchart of a process for a client device to satisfy pre-download conditions according to an embodiment.

FIG. **8**B is a flowchart of a process for a client device to satisfy pre-install conditions according to an embodiment.

FIG. **8**C is a flowchart of a process for a client device to install a software update according to an embodiment.

FIG. **9**A is a flowchart of a process for a client device to perform software updating of head units and back plates according to an embodiment.

FIG. **9**B is a flowchart of a process for a client device to determine whether a back plate needs an update according to an embodiment.

FIG. **10** is a flowchart of a process for a remote server (e.g., a registration server **512**) to perform software updating according to an embodiment.

FIG. **11** is a block diagram of a special-purpose computer system according to an embodiment.

DETAILED DESCRIPTION

As described further herein, one or more intelligent, multi-sensing, network-connected devices can be used to promote user comfort, convenience, safety and/or cost savings. FIG. **1**A illustrates an example of general device components which can be included in an intelligent, network-connected device **100** (i.e., "device"). Each of one, more or all devices **100** within a system of devices can include one or more sensors **102**, a user-interface component **104**, a power supply (e.g., including a power connection **106** and/or battery **108**), a communications component **110**, a modularity unit (e.g., including a docking station **112** and replaceable module **114**) and intelligence components **116**. Particular sensors **102**, user-interface components **104**, power-supply configurations, communications components **110**, modularity units and/or intelligence components **116** can be the same or similar across devices **100** or can vary depending on device type or model.

By way of example and not by way of limitation, one or more sensors **102** in a device **100** may be able to, e.g., detect acceleration, temperature, humidity, water, supplied power, proximity, external motion, device motion, sound signals, ultrasound signals, light signals, fire, smoke, carbon monoxide, global-positioning-satellite (GPS) signals, or radio-frequency (RF) or other electromagnetic signals or fields. Thus, for example, sensors **102** can include temperature sensor(s), humidity sensor(s), hazard-related sensor(s) or other environmental sensor(s), accelerometer(s), microphone(s), optical sensors up to and including camera(s) (e.g., charged-coupled-device or video cameras), active or passive radiation sensors, GPS receiver(s) or radio-frequency identification detector(s). While FIG. **1** illustrates an embodiment with a single sensor, many embodiments will include multiple sensors. In some instances, device **100** includes one or more primary sensors and one or more secondary sensors. The primary sensor(s) can sense data central to the core operation of the device (e.g., sensing a temperature in a thermostat or sensing smoke in a smoke detector). The secondary sensor(s) can sense other types of data (e.g., motion, light or sound), which can be used for energy-efficiency objectives or smart-operation objectives. In some instances, an average user may even be unaware of an existence of a secondary sensor.

One or more user-interface components **104** in device **100** may be configured to present information to a user via a visual display (e.g., a thin-film-transistor display or organic light-emitting-diode display) and/or an audio speaker. User-interface component **104** can also include one or more user-input components to receive information from a user, such as a touchscreen, buttons, scroll component (e.g., a movable or virtual ring component), microphone or camera (e.g., to detect gestures). In one embodiment, user-input component **104** includes a click-and-rotate annular ring component, wherein a user can interact with the component by rotating the ring (e.g., to adjust a setting) and/or by clicking the ring inwards (e.g., to select an adjusted setting or to select an option). In another embodiment, user-input component **104** includes a camera, such that gestures can be detected (e.g., to indicate that a power or alarm state of a device is to be changed).

A power-supply component in device **100** may include a power connection **106** and/or local battery **108**. For example, power connection **106** can connect device **100** to a power source such as a line voltage source. In some instances, con-

nection **106** to an AC power source can be used to repeatedly charge a (e.g., rechargeable) local battery **108**, such that battery **108** can later be used to supply power if needed in the event of an AC power disconnection or other power deficiency scenario.

A communications component **110** in device **100** can include a component that enables device **100** to communicate with a central server or a remote device, such as another device described herein or a portable user device. Communications component **110** can allow device **100** to communicate via, e.g., Wi-Fi, ZigBee, 3G/4G wireless, CAT6 wired Ethernet, HomePlug or other powerline communications method, telephone, or optical fiber, by way of non-limiting examples. Communications component **110** can include a wireless card, an Ethernet plug, or another transceiver connection. In some embodiments, the communications component **110** facilitates communication with a central server to synchronize information between device **100**, the central server, and in some cases additional devices. Techniques for synchronization data between such devices as further described in U.S. patent application Ser. No. 13/624,892, filed Sep. 22, 2012, the contents of which are incorporated by reference in their entirety for all purposes. In some embodiments, the communications component **110** also or alternatively facilitates communication with a software update server to acquire software updates for the device **100** as further described herein.

A modularity unit in device **100** can include a static physical connection, and a replaceable module **114**. Thus, the modularity unit can provide the capability to upgrade replaceable module **114** without completely reinstalling device **100** (e.g., to preserve wiring). The static physical connection can include a docking station **112** (which may also be termed an interface box) that can attach to a building structure. For example, docking station **112** could be mounted to a wall via screws or stuck onto a ceiling via adhesive. Docking station **112** can, in some instances, extend through part of the building structure. For example, docking station **112** can connect to wiring (e.g., to 120V line voltage wires) behind the wall via a hole made through a wall's sheetrock. Docking station **112** can include circuitry such as power-connection circuitry **106** and/or AC-to-DC powering circuitry and can prevent the user from being exposed to high-voltage wires. Docking station **112** may also or alternatively include control circuitry for actuating (i.e., turning on and off) elements of an HVAC system, such as a heating unit (for heating the building structure), an air-condition unit (for cooling the building structure), and/or a ventilation unit (for circulating air throughout the building structure). In some instances, docking stations **112** are specific to a type or model of device, such that, e.g., a thermostat device includes a different docking station than a smoke detector device. In some instances, docking stations **112** can be shared across multiple types and/or models of devices **100**.

Replaceable module **114** of the modularity unit can include some or all sensors **102**, processors, user-interface components **104**, batteries **108**, communications components **110**, intelligence components **116** and so forth of the device. Replaceable module **114** can be configured to attach to (e.g., plug into or connect to) docking station **112**. In some instances, a set of replaceable modules **114** are produced with the capabilities, hardware and/or software, varying across the replaceable modules **114**. Users can therefore easily upgrade or replace their replaceable module **114** without having to replace all device components or to completely reinstall device **100**. For example, a user can begin with an inexpensive device including a first replaceable module with limited intelligence and software capabilities. The user can then easily upgrade the device to include a more capable replaceable module. As another example, if a user has a Model #1 device in their basement, a Model #2 device in their living room, and upgrades their living-room device to include a Model #3 replaceable module, the user can move the Model #2 replaceable module into the basement to connect to the existing docking station. The Model #2 replaceable module may then, e.g., begin an initiation process in order to identify its new location (e.g., by requesting information from a user via a user interface).

Intelligence components **116** of the device can support one or more of a variety of different device functionalities. Intelligence components **116** generally include one or more processors configured and programmed to carry out and/or cause to be carried out one or more of the advantageous functionalities described herein. The intelligence components **116** can be implemented in the form of general-purpose processors carrying out computer code stored in local memory (e.g., flash memory, hard drive, random access memory), special-purpose processors or application-specific integrated circuits, combinations thereof, and/or using other types of hardware/firmware/software processing platforms. The intelligence components **116** can furthermore be implemented as localized versions or counterparts of algorithms carried out or governed remotely by central servers or cloud-based systems, such as by virtue of running a Java virtual machine (JVM) that executes instructions provided from a cloud server using Asynchronous Javascript and XML (AJAX) or similar protocols. By way of example, intelligence components **116** can be intelligence components **116** configured to detect when a location (e.g., a house or room) is occupied, up to and including whether it is occupied by a specific person or is occupied by a specific number of people (e.g., relative to one or more thresholds). Such detection can occur, e.g., by analyzing microphone signals, detecting user movements (e.g., in front of a device), detecting openings and closings of doors or garage doors, detecting wireless signals, detecting an IP address of a received signal, or detecting operation of one or more devices within a time window. Intelligence components **116** may include image-recognition technology to identify particular occupants or objects.

In some instances, intelligence components **116** can be configured to predict desirable settings and/or to implement those settings. For example, based on the presence detection, intelligence components **116** can adjust device settings to, e.g., conserve power when nobody is home or in a particular room or to accord with user preferences (e.g., general at-home preferences or user-specific preferences). As another example, based on the detection of a particular person, animal or object (e.g., a child, pet or lost object), intelligence components **116** can initiate an audio or visual indicator of where the person, animal or object is or can initiate an alarm or security feature if an unrecognized person is detected under certain conditions (e.g., at night or when lights are out). As yet another example, intelligence components **116** can detect hourly, weekly or even seasonal trends in user settings and adjust settings accordingly. For example, intelligence components **116** can detect that a particular device is turned on every week day at 6:30 am, or that a device setting is gradually adjusted from a high setting to lower settings over the last three hours. Intelligence components **116** can then predict that the device is to be turned on every week day at 6:30 am or that the setting should continue to gradually lower its setting over a longer time period.

In some instances, devices can interact with each other such that events detected by a first device influences actions of a second device. For example, a first device can detect that a

user has pulled into a garage (e.g., by detecting motion in the garage, detecting a change in light in the garage or detecting opening of the garage door). The first device can transmit this information to a second device, such that the second device can, e.g., adjust a home temperature setting, a light setting, a music setting, and/or a security-alarm setting. As another example, a first device can detect a user approaching a front door (e.g., by detecting motion or sudden light-pattern changes). The first device can, e.g., cause a general audio or visual signal to be presented (e.g., such as sounding of a doorbell) or cause a location-specific audio or visual signal to be presented (e.g., to announce the visitor's presence within a room that a user is occupying).

FIG. **1**B illustrates an intelligent, network-connected device **100** having a replaceable module **114** (e.g., a head unit) and a docking station **112** (e.g., a back plate) for ease of installation, configuration, and upgrading according to some embodiments. As is described hereinabove, device **100** may be wall mounted, have a circular shape, and have an outer rotatable ring **120** (that may be, e.g., part of user interface **104**) for receiving user input. Outer rotatable ring **120** allows the user to make adjustments, such as selecting a new target temperature. For example, by rotating outer ring **120** clockwise, a target setpoint temperature can be increased, and by rotating the outer ring **120** counter-clockwise, the target setpoint temperature can be decreased.

Device **100** has a cover **122** that includes a display **124** (that may be, e.g., part of user interface **104**). Head unit **114** slides onto back plate **112**. Display **124** may display a variety of information depending on, e.g., a current operational state of the device **100**, direct user interaction with the device via ring **120**, sensed presence of the user via, e.g., a proximity sensor **102** (such as a passive infrared motion sensor), remote user interaction with the device via a remote access device, etc. For example, display **124** may display central numerals that are representative of a current setpoint temperature.

According to some embodiments the connection of the head unit **114** to back plate **112** can be accomplished using magnets, bayonet, latches and catches, tabs or ribs with matching indentations, or simply friction on mating portions of the head unit **114** and back plate **112**. According to some embodiments, the head unit **114** includes battery **108**, communications component **110**, intelligence components **116**, and a display driver **126** (that may be, e.g., part of user interface **104**). Battery **108** may be recharged using recharging circuitry (that may be, e.g., part of intelligence components **116** and/or may be included in the back plate **112**) that uses power from the back plate **112** that is either obtained via power harvesting (also referred to as power stealing and/or power sharing) from the HVAC system control circuit(s) or from a common wire, if available, as described in further detail in commonly assigned co-pending U.S. patent application Ser. Nos. 13/034,674 and 13/034,678, both filed Feb. 24, 2011, and U.S. patent application Ser. No. 13/267,871, filed Oct. 6, 2011, all of which are incorporated by reference herein in their entirety for all purposes. According to some embodiments, battery **108** is a rechargeable single cell lithium-ion, or a lithium-polymer battery.

Back plate **112** includes electronics **130** and a temperature sensor **132** (that may be, e.g., one of sensors **102**) in housing **134**, which are ventilated via vents **136**. Temperature sensor **132** allows the back plate **112** to operate as a fully functional thermostat even when not connected to the headunit **114**. Wire connectors **138** are provided to allow for connection to HVAC system wires, such as connection to wires for actuating components of the HVAC system, wires for receiving power from the HVAC system, etc. Connection terminal **140** is a male or female plug connector that provides electrical connections between the head unit **114** and back plate **112**. Various arrangements for connecting to and controlling an HVAC system are further described in U.S. patent application Ser. Nos. 13/034,674 and 13/034,678, supra.

In some embodiments, the back plate electronics **130** includes an MCU processor, and driver circuitry for opening and closing the HVAC control circuits, thereby turning on and turning off the one or more HVAC functions such as heating and cooling. The electronics **130** also includes flash memory which is used to store a series of programmed settings that take effect at different times of the day, such that programmed setpoint (i.e., desired temperature) changes can be carried out even when the headunit **114** is not attached to the back plate **112**. According to some embodiments, the electronics **130** also includes power harvesting circuitry (that may be in addition or alternatively to that provided in headunit **114**) to obtain power from the HVAC control circuit(s) even when an HVAC common power wire is not available.

Device **100** in certain embodiments is an intelligent, network-connected learning thermostat that includes various components such as a head unit, a back plate, a user interface, communications components, intelligent components, etc. However, it will be appreciated by those skilled in the art that devices that perform the various operations described herein could operate equally well with fewer or a greater number of components than are illustrated in FIGS. **1**A and **1**B. Thus, the depiction of device **100** in FIGS. **1**A and **1**B should be taken as being illustrative in nature, and not limiting to the scope of the present teachings.

FIG. **2** illustrates an example of a smart home environment **200** within which one or more of the devices, methods, systems, services, and/or computer program products described further herein can be applicable. The depicted smart home environment includes a structure **250**, which can include, e.g., a house, office building, garage, or mobile home. It will be appreciated that devices can also be integrated into a smart home environment that does not include an entire structure **250**, such as an apartment, condominium, or office space. Further, the smart home environment can control and/or be coupled to devices outside of the actual structure **250**. Indeed, several devices in the smart home environment need not physically be within the structure **250** at all. For example, a device controlling a pool heater or irrigation system can be located outside of the structure **250**.

The depicted structure **250** includes a plurality of rooms **252**, separated at least partly from each other via walls **254**. The walls **254** can include interior walls or exterior walls. Each room can further include a floor **256** and a ceiling **258**. Devices can be mounted on, integrated with and/or supported by a wall **254**, floor or ceiling.

The smart home depicted in FIG. **2** includes a plurality of devices, including intelligent, multi-sensing, network-connected devices that can integrate seamlessly with each other and/or with cloud-based server systems to provide any of a variety of useful smart home objectives. One, more or each of the devices illustrated in the smart home environment can include one or more sensors, a user interface, a power supply, a communications component, a modularity unit and intelligent software as described with respect to FIGS. **1**A and **1**B. Further, one, more or each of the devices illustrated in FIG. **2** can acquire software updates from a software update server, such as a software update server included in or coupled to remote server **264**.

An intelligent, multi-sensing, network-connected thermostat **202** can detect ambient climate characteristics (e.g., temperature and/or humidity) and control a heating, ventilation

and air-conditioning (HVAC) system **203**. One or more intelligent, network-connected, multi-sensing hazard detection units **204** can detect the presence of a hazardous substance and/or a hazardous condition in the home environment (e.g., smoke, fire, or carbon monoxide). One or more intelligent, multi-sensing, network-connected entryway interface devices **206**, which can be termed a "smart doorbell", can detect a person's approach to or departure from a location, control audible functionality, announce a person's approach or departure via audio or visual means, or control settings on a security system (e.g., to activate or deactivate the security system).

Each of a plurality of intelligent, multi-sensing, network-connected wall light switches **208** can detect ambient lighting conditions, detect room-occupancy states and control a power and/or dim state of one or more lights. In some instances, light switches **208** can further or alternatively control a power state or speed of a fan, such as a ceiling fan. Each of a plurality of intelligent, multi-sensing, network-connected wall plug interfaces **210** can detect occupancy of a room or enclosure and control supply of power to one or more wall plugs (e.g., such that power is not supplied to the plug if nobody is at home). The smart home may further include a plurality of intelligent, multi-sensing, network-connected appliances **212**, such as refrigerators, stoves and/or ovens, televisions, washers, dryers, lights (inside and/or outside the structure **250**), stereos, intercom systems, garage-door openers, floor fans, ceiling fans, whole-house fans, wall air conditioners, pool heaters **214**, irrigation systems **216**, security systems, and so forth. While descriptions of FIG. **2** can identify specific sensors and functionalities associated with specific devices, it will be appreciated that any of a variety of sensors and functionalities (such as those described throughout the specification) can be integrated into the device.

In addition to containing processing and sensing capabilities, each of the devices within the smart home environment **200** can be capable of data communications and information sharing with any other devices within the smart home environment **200**, as well as to any devices outside the smart home environment **240** such as the access device **266** and/or remote server **264**. The devices can send and receive communications via any of a variety of custom or standard wireless protocols (Wi-Fi, ZigBee, 6LoWPAN, etc.) and/or any of a variety of custom or standard wired protocols (CAT6 Ethernet, HomePlug, etc.). The wall plug interfaces **210** can serve as wireless or wired repeaters, and/or can function as bridges between (i) devices plugged into AC outlets and communicating using Homeplug or other power line protocol, and (ii) devices that are not plugged into AC outlets.

For example, a first device can communicate with a second device via a wireless router **260**. A device can further communicate with remote devices via a connection to a network, such as the Internet **262**. Through the Internet **262**, the device can communicate with a central (i.e., remote) server or a cloud-computing system **264**. The remote server or cloud-computing system **264** can be associated with a manufacturer, support entity or service provider associated with the device. In one embodiment, a user may be able to contact customer support using a device itself rather than needing to use other communication means such as a telephone or Internet-connected computer. Further, software updates can be automatically sent from the remote server or cloud-computing system **264** to devices (e.g., when available, when purchased, or at routine intervals).

Devices' network connections can further allow a user to interact with the device even if the user is not proximate to the device. For example, a user can communicate with a device (e.g., thermostat **202**) using a computer (e.g., a desktop computer, laptop computer, or tablet) or other portable electronic device (e.g., a smartphone) **266**. A webpage or app can be configured to receive communications from the user and control the device based on the communications and/or to present information about the device's operation to the user. For example, the user can view a current setpoint temperature for a device and adjust it using a computer. The user can be in the structure during this remote communication or outside the structure.

The smart home environment **200** also can include a variety of non-communicating legacy appliances **240**, such as old conventional washer/dryers, refrigerators, and the like which can be controlled, albeit coarsely (ON/OFF), by virtue of the wall plug interfaces **210**. The smart home can further include a variety of partially communicating legacy appliances **242**, such as IR-controlled wall air conditioners or other IR-controlled devices, which can be controlled by IR signals provided by the hazard detection units **204** or the light switches **208**.

Smart home **200** in certain embodiments is an environment including a number of client devices and access devices all operable to communicate with one another and perform synchronization via a remote server. However, it will be appreciated by those skilled in the art that such an environment could operate equally well having fewer or a greater number of components than are illustrated in FIG. **2**. Thus, the depiction of the smart home environment **200** in FIG. **2** should be taken as being illustrative in nature, and not limiting to the scope of the present teachings.

FIG. **3** illustrates a network-level view of an extensible devices and services platform with which the smart home of FIGS. **1** and/or **2** can be integrated. Each of the intelligent, network-connected devices discussed with reference to FIG. **2** can communicate with one or more remote servers or cloud computing systems **264**. The communication can be enabled by establishing connection to the Internet **262** either directly (for example, using 3G/4G connectivity to a wireless carrier), though a hubbed network (which can be a scheme ranging from a simple wireless router, for example, up to and including an intelligent, dedicated whole-home control node), or through any combination thereof.

The remote server or cloud-computing system **264** can collect operation data **302** from the smart home devices. For example, the devices can routinely transmit operation data or can transmit operation data in specific instances (e.g., when requesting customer support). The remote server or cloud-computing architecture **264** can further provide one or more services **304**. The services **304** can include, e.g., software update, customer support, sensor data collection/logging, remote access, remote or distributed control, or use suggestions (e.g., based on collected operation data **304** to improve performance, reduce utility cost, etc.). Data associated with the services **304** can be stored at the remote server or cloud-computing system **264** and the remote server or cloud-computing system **264** can retrieve and transmit the data at an appropriate time (e.g., at regular intervals, upon receiving request from a user, etc.).

One salient feature of the described extensible devices and services platform, as illustrated in FIG. **3**, is a processing engine **306**, which can be concentrated at a single data processing server **307** (which may be included in or separate from remote server **264**) or distributed among several different computing entities without limitation. Processing engine **306** can include engines configured to receive data from a set of devices (e.g., via the Internet or a hubbed network), to index the data, to analyze the data and/or to generate statistics

based on the analysis or as part of the analysis. The analyzed data can be stored as derived data **308**. Results of the analysis or statistics can thereafter be transmitted back to a device providing ops data used to derive the results, to other devices, to a server providing a webpage to a user of the device, or to other non-device entities. For example, use statistics, use statistics relative to use of other devices, use patterns, and/or statistics summarizing sensor readings can be transmitted. The results or statistics can be provided via the Internet **262**. In this manner, processing engine **306** can be configured and programmed to derive a variety of useful information from the operational data obtained from the smart home. A single server can include one or more engines.

The derived data can be highly beneficial at a variety of different granularities for a variety of useful purposes, ranging from explicit programmed control of the devices on a per-home, per-neighborhood, or per-region basis (for example, demand-response programs for electrical utilities), to the generation of inferential abstractions that can assist on a per-home basis (for example, an inference can be drawn that the homeowner has left for vacation and so security detection equipment can be put on heightened sensitivity), to the generation of statistics and associated inferential abstractions that can be used for government or charitable purposes. For example, the processing engine **306** can generate statistics about device usage across a population of devices and send the statistics to device users, service providers or other entities (e.g., that have requested or may have provided monetary compensation for the statistics). As specific illustrations, statistics can be transmitted to charities **322**, governmental entities **324** (e.g., the Food and Drug Administration or the Environmental Protection Agency), academic institutions **326** (e.g., university researchers), businesses **328** (e.g., providing device warranties or service to related equipment), or utility companies **330**. These entities can use the data to form programs to reduce energy usage, to preemptively service faulty equipment, to prepare for high service demands, to track past service performance, etc., or to perform any of a variety of beneficial functions or tasks now known or hereinafter developed.

FIG. **4** illustrates an abstracted functional view of the extensible devices and services platform of FIG. **3**, with particular reference to the processing engine **306** as well as the devices of the smart home. Even though the devices situated in the smart home will have an endless variety of different individual capabilities and limitations, they can all be thought of as sharing common characteristics in that each of them is a data consumer **402** (DC), a data source **404** (DS), a services consumer **406** (SC), and a services source **408** (SS). Advantageously, in addition to providing the essential control information needed for the devices to achieve their local and immediate objectives, the extensible devices and services platform can also be configured to harness the large amount of data that is flowing out of these devices. In addition to enhancing or optimizing the actual operation of the devices themselves with respect to their immediate functions, the extensible devices and services platform can also be directed to "repurposing" that data in a variety of automated, extensible, flexible, and/or scalable ways to achieve a variety of useful objectives. These objectives may be predefined or adaptively identified based on, e.g., usage patterns, device efficiency, and/or user input (e.g., requesting specific functionality).

For example, FIG. **4** shows processing engine **306** as including a number of paradigms **410**. Processing engine **306** can include a managed services paradigm **410***a* that monitors and manages primary or secondary device functions. The device functions can include ensuring proper operation of a device given user inputs, estimating that (e.g., and responding to) an intruder is or is attempting to be in a dwelling, detecting a failure of equipment coupled to the device (e.g., a light bulb having burned out), implementing or otherwise responding to energy demand response events, or alerting a user of a current or predicted future event or characteristic. Processing engine **306** can further include an advertising/communication paradigm **410***b* that estimates characteristics (e.g., demographic information), desires and/or products of interest of a user based on device usage. Services, promotions, products or upgrades can then be offered or automatically provided to the user. Processing engine **306** can further include a social paradigm **410***c* that uses information from a social network, provides information to a social network (for example, based on device usage), and/or processes data associated with user and/or device interactions with the social network platform. For example, a user's status as reported to their trusted contacts on the social network could be updated to indicate when they are home based on light detection, security system inactivation or device usage detectors. As another example, a user may be able to share device-usage statistics with other users. Processing engine **306** can include a challenges/rules/compliance/rewards paradigm **410***d* that informs a user of challenges, rules, compliance regulations and/or rewards and/or that uses operation data to determine whether a challenge has been met, a rule or regulation has been complied with and/or a reward has been earned. The challenges, rules or regulations can relate to efforts to conserve energy, to live safely (e.g., reducing exposure to toxins or carcinogens), to conserve money and/or equipment life, to improve health, etc.

Processing engine **306** can integrate or otherwise utilize extrinsic information **416** from extrinsic sources to improve the functioning of one or more processing paradigms. Extrinsic information **416** can be used to interpret operational data received from a device, to determine a characteristic of the environment near the device (e.g., outside a structure that the device is enclosed in), to determine services or products available to the user, to identify a social network or social-network information, to determine contact information of entities (e.g., public-service entities such as an emergency-response team, the police or a hospital) near the device, etc., to identify statistical or environmental conditions, trends or other information associated with a home or neighborhood, and so forth.

An extraordinary range and variety of benefits can be brought about by, and fit within the scope of, the described extensible devices and services platform, ranging from the ordinary to the profound. Thus, in one "ordinary" example, each bedroom of the smart home can be provided with a smoke/fire/CO alarm that includes an occupancy sensor, wherein the occupancy sensor is also capable of inferring (e.g., by virtue of motion detection, facial recognition, audible sound patterns, etc.) whether the occupant is asleep or awake. If a serious fire event is sensed, the remote security/monitoring service or fire department is advised of how many occupants there are in each bedroom, and whether those occupants are still asleep (or immobile) or whether they have properly evacuated the bedroom. While this is, of course, a very advantageous capability accommodated by the described extensible devices and services platform, there can be substantially more "profound" examples that can truly illustrate the potential of a larger "intelligence" that can be made available. By way of perhaps a more "profound" example, the same data bedroom occupancy data that is being used for fire safety can also be "repurposed" by the processing engine **306** in the context of a social paradigm of neighborhood child development and education. Thus, for example, the same bedroom occupancy and motion data discussed in

the "ordinary" example can be collected and made available for processing (properly anonymized) in which the sleep patterns of schoolchildren in a particular ZIP code can be identified and tracked. Localized variations in the sleeping patterns of the schoolchildren may be identified and correlated, for example, to different nutrition programs in local schools.

FIG. **5** depicts a system **500** that implements techniques for updating software on a client device according to an embodiment. System **500** includes a remote server **510** that is remote from and communicatively coupled to one or more client devices **520** via a network **530**.

Client devices **520** include a variety of electronic devices including upgradeable computer software operable to control one or more functions of the device. In some embodiments, client device **520** may take the form of one or more of a variety of electronic devices described herein, such as device **100** (FIGS. **1**A and **1**B), thermostat **202** (FIG. **2**), hazard detection unit **204** (FIG. **2**), entryway interface device **206** (FIG. **2**), light switch **208** (FIG. **2**), wall plug interface **210** (FIG. **2**), appliance **212**, etc.

Remote server **510** is a single or distributed computing entity in communication with the client devices **520** over network **530**. The remote server **510** may be operable to perform any one or more of a variety of operations, such as providing software updates to client devices **520**, synchronizing data between elements of the remote server **510** and the client device **520**, synchronization data between multiple client devices **520**, etc. In some particular embodiments, remote server **520** may take the form of one or more of the remote servers described herein, such as remote server **264** (FIGS. **2** and **3**).

The remote server **510** according to certain embodiments includes a registration server **512**, one or more synchronization servers **514**A through **514**N, a storage element **516**, and a software update server **518**. In some embodiments the software update server **518** may not be included in the remote server **510** but rather may, e.g., be located remotely from the remote server **510**.

The registration server **512** may act as a first point of contact for the client devices **520**. For example, a client device **520** may have a location identifier (e.g., a URL) of the registration server **512** hardcoded therein, so that on initialization or reconnect, the client device **520** may always contact registration server **512**. Among other things, the registration server **512** may identify one of the synchronization servers **514**A through **514**N which is responsible for synchronizing information at the client device **520** with information at the storage element **516**, and provide the identity of the selected synchronization server to the client device **520**. The client devices may then subsequently connect to the identified synchronization server which will subsequently synchronize the states of the client device **520** with each other and with the storage element **516**.

In synchronizing states, the selected synchronization server may propagate state changes made at the client device **520** to the storage element **516**, or similarly may propagate state changes made at the client device **520** to the storage element **516**. For example, state changes made at a thermostat **202** may be propagated to the storage element **516**. In some embodiments, client devices **520** may include may include monitoring devices (e.g., thermostat **202**) that generate data (e.g., data indicative of temperature, humidity, motion, etc.). Client devices **520** may also include access devices (e.g., portable electronic device **266**) that provide access to data generated by associated (e.g., paired) monitoring devices and, in some embodiments, control of such monitoring devices. The synchronization server may thus propagate state changes between the monitoring devices and the access devices so that all paired devices (e.g., devices associated with a common user account) eventually have the same state of information. Some specific techniques for synchronizing device states are described U.S. patent application Ser. No. 13/624,892, supra. Further, some specific techniques for pairing devices are described in U.S. patent application Ser. No. 13/275,311, filed Oct. 17, 2011, the contents of which are incorporated by reference in their entirety for all purposes.

In at least one embodiment, the software update server **518** includes packages of computer software for updating the software executing on the client devices **520**. The packages of computer software may entirely replace the software executing on the client devices **520** or, in some embodiments, may provide incremental updates to the software executing on the client devices **520**. Accordingly, the packages may include operation systems, software applications, etc. The software update server **518** may include packages of computer software for different client devices **520** or, in some embodiments, multiple software update servers **518** may be provided where one or more update server **518** includes computer software packages for one or more types of client devices **520**.

Network **530** is any suitable network for enabling communications between various entities, such as between client devices **520** and remote server **510**. Such a network may include, for example, a local area network, a wide-area network, a virtual private network, the Internet, an intranet, an extranet, a public switched telephone network, an infrared network, a wireless network, a wireless data network, a cellular network, or any other such network or combination thereof. The network may, furthermore, incorporate any suitable network topology. Network **530** may utilize any suitable protocol, and communication over the network **530** may be enabled by wired or wireless connections, and combinations thereof.

System **500** in certain embodiments is a distributed computing environment with a remote server **510** including various components communicatively coupled to one or more client devices **520**. However, it will be appreciated by those skilled in the art that such a system could operate equally well with fewer or a greater number of components than are illustrated in FIG. **5**. Thus, the depiction of system **500** in FIG. **5** should be taken as being illustrative in nature, and not limiting to the scope of the present teachings.

FIG. **6** illustrates a communication sequence **600** of a process for performing software updates according to an embodiment. To facilitate understanding, the process **600** is described with reference to FIG. **1** through FIG. **5**, although it should be understood that embodiments of the process **600** are not limited to the exemplary systems and apparatus described with reference to FIG. **1** through FIG. **5**.

In operation **602**, a client device (e.g., device **520**) contacts a registration server (e.g., registration server **512**). The client device **520** may contact the registration server **512** at a variety of times and in response to a variety of situations. For example, the client device **520** may contact the registration server **512** periodically (e.g., once every 12 hours, once every 24 hours, once every 36 hours, once every time period less than 12 hours, in a range from 12 hours to 36 hours, or more than 36 hours) to, e.g., determine whether the client device **520** should continue to synchronize with a previously identified synchronization server **514** or a newly identified synchronization server **514**. For another example, the client device **520** may contact the registration server **512** in the event the client device **520** does not have the credentials (i.e., authorization requirements) to communicate with other elements

(e.g., a synchronization server **514**) of the remote server **510**. For yet another example, the client device **520** may contact the registration server **512** upon initial setup/installation of the client device **520** to, e.g., acquire credentials for communicating with other elements of remote server **510**, acquire target locations of other elements of remote server **510**, etc. As part of its communications with the registration server **512**, the client device **520** may communicate a device identifier that uniquely identifies the client device **520**. Details of these and other situations in which a client device contacts a registration server are described in U.S. patent application Ser. No. 13/624,892, supra.

In operation **604**, the registration server **512** may provide information indicating an appropriate software version to the client device **520**. Information indicating the appropriate software version may indicate a version of software that the registration server desires the client device to execute. The registration server **512** may determine the appropriate software version for the client device based, e.g., on the device identifier communicated from the client device **520**. Using the device identifier, the registration server **512** may determine what type of device the client device **520** is (e.g., a thermostat, an entryway interface device, a wall light switch, a wall plug interface, etc.), and based on the type of device determine the appropriate software version.

In operation **606**, the registration server **512** may provide a target location (e.g., a URI) of a software update server or system (e.g., software update server **518**) where the client device **520** may acquire the software update. The registration server **512** may determine the target location based, e.g., on the appropriate software version.

In operation **608**, the registration server **512** provides an indicator (e.g., a flag, a message, etc.) indicating whether the software update is a critical or non-critical update. A critical update may be one which should be installed by the client device **520** regardless of whether the software update is acquired during an initial setup of the client device **520** or during subsequent (i.e., post-setup) operation of the client device **520**. Accordingly, a client device **520** should install a critical update even if doing so interrupts the initial setup of the client device **520**. In contrast, a client device **520** should install a non-critical update only if doing so does not interrupt the initial setup of the client device **520**.

In operation **610**, after determining that it should download a software update, the client device **520** sends a request for the software update to the software update server **518**. The request is sent to the software update server **518** identified in the communication of operation **606**. In response and in operation **612**, the client device **520** receives the software update from the software update server **518**. The client device **520** may then, at a suitable time, install the downloaded software update.

It should be appreciated that the specific operations illustrated in FIG. **6** provide a particular process for performing software updates according to various embodiments. Other sequences of operations may also be performed according to alternative embodiments. For example, alternative embodiments of the present invention may perform the operations outlined above in a different order. Moreover, the individual operations illustrated in FIG. **6** may include multiple sub-operations that may be performed in various sequences as appropriate to the individual operations. Furthermore, additional operations may be added or existing operations removed depending on the particular applications. One of ordinary skill in the art would recognize and appreciate many variations, modifications, and alternatives.

FIG. **7** is a flowchart of a process **700** for a client device to perform software updating according to an embodiment. In operation **702**, the client device (e.g., client device **520**) receives information indicating an appropriate software version, which indicates a version of software that the registration server **512** desires the client device to execute. The client device **520** may receive such information from a registration server (e.g., registration server **512**) in response to contacting the registration server.

In operation **704**, the client device **520** receives a target location (e.g., a URI) of a software update server or system (e.g., software update server **518**) where the client device **520** may acquire the software update. The client device **520** may receive such information from registration server **512** in response to contacting the registration server.

In operation **706**, the client device **520** receives a criticality indicator (e.g., a flag, a message, etc.) indicating whether the software update is a critical or non-critical update. The client device **520** may receive the criticality indicator from the registration server **512** in response to contacting the registration server.

In operation **708**, the client device **520** ensures that one or more pre-download conditions are satisfied. Pre-download conditions are conditions (e.g., states of the client device **520**, elements of the system **500** in which client device **520** exists, and/or of the environment in which the client device **520** is located) that must be satisfied prior to the client device **520** downloading or otherwise acquiring the software update. For example, pre-download conditions may include ensuring that the client device **520** has a battery charge sufficient to fully download the software update. Various pre-download conditions are further described with reference to FIG. **8**A. Once the pre-download conditions are satisfied, processing continues to operation **710**.

In operation **710**, the client device **520** downloads the software update. In one embodiment, the client device **520** may send a request for the software update to the software update server identified in operation **704**. In response to sending such a request, the client device **520** may receive the software update from the identified software update server.

After the software update is downloaded, processing continues to operation **712** where the client device **520** determines whether the download occurred as a result of or during a process of installing the device. For example, a user may purchase a thermostat **202** from a retail outlet and, upon acquiring the thermostat **202**, install the thermostat **202** into structure **250** either themselves or with the assistance of a professional installer. Installation of the device may include one or more of a variety of aspects, such as hardware installation (e.g., mechanically connecting the device to a wall of the structure **250**, electrically coupling the device to other elements associated with structure **250** such as HVAC **203**, etc.) and/or software configuration (e.g., configuring the device to connect to a local wireless network, indicating to the device characteristics of an HVAC **203** the device is coupled to, testing the electrical coupling of the device to the HVAC **203**, naming the device, pairing the device to a user account, etc.). Some specific techniques for installing a device are described in U.S. patent application Ser. No. 13/038,191 filed Mar. 1, 2011, the contents of which are incorporated by reference in their entirety for all purposes.

If it is determined that the download occurred as a result of or during a process of installing the device, processing continues to operation **714** where the device determines whether the software update is critical or non-critical. To make such a determination the device may, e.g., read the criticality indicator received in operation **706**.

If the software update is not critical, then processing continues to operation **716** where the device waits before installing the software update. The device **520** waits a suitable amount of time to reduce the likelihood that installation of the software update will interfere with installation of the device **520**. For example, installation of a device may require on average between 10 and 15 minutes. In such cases, the device **520** may wait 20 minutes, 30 minutes, 40 minutes, an amount of time less than 20 minutes, greater than 40 minutes, or in a range from 20 to 40 minutes. For another example, installation of a device may require 30 minutes on average. In such cases, the device **520** may wait 35 minutes, 45 minutes, 55 minutes, an amount of time less than 35 minutes, greater than 55 minutes, or in a range from 35 to 45 minutes. Accordingly, in at least one embodiment, the device may wait a certain amount of time greater than the expected installation time. In some cases, the device may wait on the order of hours, days, or even weeks, rather than minutes.

After waiting in operation **716**, after determining that the software update is critical in operation **714**, or after determining that the software download did not occur as a result of or during a process of installing the device in operation **712**, processing may continue to operation **718**. In operation **718** the client device **520** ensures that one or more pre-install conditions are satisfied. Pre-install conditions are conditions (e.g., states of the client device **520**, elements of the system **500** in which client device **520** exists, and/or of the environment in which the client device **520** is located) that must be satisfied prior to the client device **520** installing the software update. For example, pre-install conditions may include ensuring that the client device **520** has a battery charge sufficient to install the software update. Various pre-install conditions are further described with reference to FIG. **8**B. Once the pre-install conditions are satisfied, processing continues to operation **720**, where the client device **520** installs the software update. Various techniques for installing the software update are further described with reference to FIG. **8**C.

During the various operations described with reference to FIG. **7**, various information (e.g., text, graphics, audio, etc.) may be communicated to the user for a variety of reasons, such as to provide a status of the download/update process, solicit feedback or action by the user, etc. For example, the user may be prompted to perform some task (such as connecting the device to a power source or waiting for the battery level of the device to reach a desired level) while the device satisfies the pre-download conditions and/or the pre-install conditions. For another example, the user may be provided information indicating a status of the download and/or install. In one particular embodiment, the information provided to the user may be determined based on whether the update is critical or not. For example, the status of a download and/or install (e.g., 20% complete, 50% complete, 70% complete, etc.) may be displayed to the user for critical updates, but may be suppressed for non-critical updates. For another example, information concerning satisfying the pre-download conditions (e.g., instructing the user to connect the head unit to the back plate) may be displayed during a critical update, but suppressed during a non-critical update. Accordingly, in a variety of embodiments the determination of whether the update is critical may thus be performed prior to actually downloading the software update and/or prior to satisfying the pre-download conditions.

It should also be recognized that user controllability of the client device may be impacted based on whether the software update is critical or noncritical. In some embodiments, the user may effectively lose control of the client device when critical updates are required. For example, the client device may ignore or otherwise be unresponsive to requests by the user (e.g., requests to change the setpoint, access menu options, etc.). Rather, the client device may instruct the user to perform certain tasks (e.g., charge the battery, wait for install, etc.) so as to ensure that the software updates are downloaded. In contrast, for non-critical updates, the user may retain control of the device and, in some cases, may be entirely unaware of the software update download and/or install since information concerning the download and/or install may be suppressed from the user.

It should be appreciated that the specific operations illustrated in FIG. **7** provide a particular process for performing software updates according to various embodiments. Other sequences of operations may also be performed according to alternative embodiments. For example, alternative embodiments of the present invention may perform the operations outlined above in a different order. Moreover, the individual operations illustrated in FIG. **7** may include multiple sub-operations that may be performed in various sequences as appropriate to the individual operations. Furthermore, additional operations may be added or existing operations removed depending on the particular applications. One of ordinary skill in the art would recognize and appreciate many variations, modifications, and alternatives.

FIG. **8**A is a flowchart of a process for a client device to satisfy pre-download conditions according to an embodiment. The process may be implemented, for example, as operation **708** described with reference to FIG. **7**.

In operation **708**A, the client device (e.g., client device **520**) determines whether the device is in an 'awake' mode (i.e., state of operation). In some embodiments, the client device **520** may operate in a plurality of different modes of operation, such as an awake mode, a sleep mode, etc. Different modes of operation illustrate different (e.g., scaled) operational characteristics of the client device **520**. When operating in an awake mode, the client device may operate with full functionality. For example, the processor(s) of the client device may be active and operating at their maximum level of activity, user display(s) may be active, wireless communications may be enabled and operable to communicate at their maximum capacity, sensor(s) may be active and sampling at their highest sampling rate, etc. In contrast, when in a non-awake mode of operation, such as a sleep mode, the client device may operate at reduced functionality as compared to the awake mode. For example, the processor(s) of the client device may be active (or some even inactive) and operating at a low or medium level of activity, user display(s) may be inactive, wireless communications may be enabled (or even disabled) and operable to communicate at a low or medium capacity, sensor(s) may be active (or even inactive) and sampling at a low or medium sampling rate, etc. Some specific examples of varying modes of operation and their characteristics are described in commonly assigned U.S. patent application Ser. No. 13/267,877, filed Oct. 6, 2011, the entire contents of which are incorporated by reference herein in their entirety for purposes.

It should be recognized that a variety of events may cause the client device to transition from a non-awake mode to an awake mode. For example, the client device may enter into an awake mode if one or more proximity infrared sensors detect an approaching user, a user physically engages the client device (e.g., a user rotates, pushes, or otherwise actuates ring **120**), a remote server **510** communicates an awake instruction to the client device **520**, etc. Some specific examples of causing client devices to change operating states are described in commonly assigned U.S. patent application Ser. No. 13/267,877, supra.

If it is determined that the client device is not in an awake mode, then processing may continue to operation **708**B where the client device waits until it is operating in an awake mode. Otherwise, processing may continue to operation **708**C.

In operation **708**C, the client device determines whether a power connection is available. In one embodiment, the client device **520** may determine whether a direct connection to a power source such as a line voltage source is available. For example, connection to an HVAC C-wire via power connection **106**. For another example, connection to a power source such as a computing device or AC/DC converter via a USB cable, power cable, or other power transmission medium. In another embodiment, the client device **520** may determine whether an indirect connection to a power source is available (e.g., power stealing from the HVAC system via power connection **106**). In yet another embodiment, the client device **520** may determine whether any of the aforementioned direct or indirect connections are available. The connections may be connections from the docking station **112** (e.g., the C-wire and/or power stealing connections) and/or from the replaceable module **114** (e.g., the USB connection). If no power connection is available, then processing may continue to operation **708**D where the client device waits for a power connection to become available. Otherwise, processing may continue to operation **708**E.

In some embodiments, determining whether a power connection is available may include determining an amount of energy available from a power source (e.g., max voltage, max current, max power, etc.), determining an amount of energy required downloading the software update (e.g., required voltage, current, power, etc. for a period of time), and determining whether the amount of energy available is equal to or greater than that required to download the software update. In one embodiment, a power connection will be deemed available if is determined that the amount of energy available is equal to or greater than that required to download the software, and in another embodiment a power connection will be deemed available if is determined that the amount of energy available is greater than that required to download the software.

As mentioned with reference to FIG. **7**, various information may be communicated to the user during the download and/or install process. For example, if it is determined that there is no power connection available, then information requesting such a power connection may be communicated to the user via, e.g., the display **124**. In some embodiments, such information may be communicated to the user only for critical updates and suppressed for non-critical updates. In other embodiments, such information may always be communicated to the user. Such information may be communicated when it is desired to cause the user to perform some sort of action (such as by connecting a power source). For example, such information may be communicated during the wait operation **708**D.

In operation **708**E, the client device determines whether it has sufficient battery charge to download the software update. In one particular embodiment, the client device **520** may determine whether the voltage of battery **108** is equal to or greater than a minimum voltage. If it is, then the client device may determine that it has sufficient battery charge, otherwise, it may determine that its battery charge in insufficient. The minimum voltage may be, e.g., 3.5V, 3.7V, 3.9V, in a range from 3.5V to 3.9V, less than 3.5V, or greater than 3.9V. If it is determined that the battery charge is insufficient, processing may continue to operation **708**F where the client device waits until it has acquired a sufficient battery charge. In some embodiments, the client device **520** may charge its battery using power transfer or power stealing techniques as previously described. Otherwise, if it is determined that the battery charge is sufficient, then at this stage the pre-download conditions may be deemed satisfied.

As mentioned, various information may be communicated to the user during the download and/or install process. For example, if it is determined that there is insufficient battery charge, then information indicating that a sufficient battery charge must be acquired prior to downloading the software update may be communicated to the user via, e.g., the display **124**. In some embodiments, such information may be communicated to the user only for critical updates and suppressed for non-critical updates. In other embodiments, such information may always be communicated to the user. Such information may be communicated when it is desired to cause the user to perform some sort of action (such as by not interfering with the device so as to allow the device to acquire a sufficient battery charge). For example, such information may be communicated during the wait operation **708**F.

In at least one embodiment, operations **708**E and **708**F may be omitted. For example, when determining whether a power connection is available includes determining whether an amount of energy available is greater than (or equal to) that required to download the software, operations **708**E and **708**F may be omitted if it is determined that the amount of energy available is greater than (or equal to) that required to download the software since, in such cases, a battery may similarly be omitted or used only for backup or post-download purposes.

FIG. **8**B is a flowchart of a process for a client device to satisfy pre-install conditions according to an embodiment. The process may be implemented, for example, as operation **708** described with reference to FIG. **7**.

In operation **718**A, the client device (e.g., client device **520**) determines whether the device is in an 'awake' mode (i.e., state of operation). This may be similar to operation **708**A, thus further description is omitted. If it is determined that the client device is not in an awake mode, then processing may continue to operation **718**B where the client device waits until it enters into an awake mode of operation. Otherwise, processing may continue to operation **718**C.

In operation **718**C, the client device determines whether it has sufficient battery charge to install the software update. This operation is similar to operation **708**D, except in this case the determination is as to whether the battery charge is sufficient to install rather than download the software update. Thus, further description is omitted. If it is determined that the battery charge is insufficient, then processing may continue to operation **718**D where the client device waits until it has obtained a battery charge sufficient to install the software update. Otherwise, processing may continue to operation **718**E.

In operation **718**E, the client device determines whether it is connected to a back plate. In some embodiments, the client device may be a modular device including a head unit **114** and a back plate **112**. In such cases, the device may determine whether the head unit **114** is connected to the back plate **112**. Connection to the back plate **112** may increase the likelihood that the battery **108** is charged throughout the installation process, that a power connection **106** is maintained, that a wireless connection to a local area network provided in smart home environment **200** (and thus remote server **510**) is maintained, etc. If it is determined that the head unit **114** is disconnected from the back plate **112**, then processing may continue to operation **718**F where the client device **520** waits until the head unit **114** is connected to the back plate **112**. Otherwise, processing may continue to operation **718**G.

As mentioned with reference to FIG. **7**, various information may be communicated to the user during the download and/or install process. For example, if it is determined that the head unit is not connected to the back plate, then information requesting the user to connect the head unit to the back plate may be communicated to the user via, e.g., the display **124**. In some embodiments, such information may be communicated to the user only for critical updates and suppressed for non-critical updates. In other embodiments, such information may always be communicated to the user. Such information may be communicated when it is desired to cause the user to perform some sort of action (such as by connecting a power source). For example, such information may be communicated during the wait operation **718**F.

In operation **718**G, the client device determines whether its display is active. In some embodiments, the client device **520** may include a display element **124**. The display element **124** may be active, in which case it displays information to a user, or inactive, in which case it does not display information to a user. If the display element **124** is active, processing may continue to operation **718**H where the client device waits until the display becomes inactive. In this fashion, the software update installation process may be hidden from the user of the device. In contrast, if the display element **124** is inactive, then processing may continue to operation **718**I.

In operation **718**I, the client device determines whether it is controlling an HVAC system coupled thereto to be active. For example, as previously described electronics **130** may activate heating systems, ventilation systems, air conditions systems, etc. via wire connectors **138**. If one or more of these systems are active, then processing may continue to operation **718**J where the client device waits until the systems become inactive. In this fashion, installation of the software update does not interrupt operation of the HVAC system. Otherwise, if it is determined that the VHAC system is not active, then the client device may determine that all pre-installation conditions are satisfied.

In some embodiments, the client device may determine that all pre-installation conditions are satisfied even if the HVAC system is active. For example, the client device may check to see how long the HVAC system has been active. If the HVAC system has been continuously active for at least a certain period of time (e.g., 6 hours, 12 hours, 18 hours, 24 hours, an amount of time in the range of 6 hours to 24 hours, less than 6 hours, or greater than 24 hours), then the client device may stop waiting and determine that the HVAC system activity pre-installation condition is satisfied. This may be particularly beneficial in situations where an HVAC system is in continuous use, e.g., in extreme conditions (e.g., extreme heat or extreme cold), where a relatively short HVAC inoperability (e.g., 5 minutes, 10 minutes, 15 minutes, etc.) resulting from installation of the software update may have a minimal impact on overall user comfort or experience.

FIG. **8**C is a flowchart of a process for a client device to install a software update according to an embodiment. The process may be implemented, for example, as operation **720** described with reference to FIG. **7**.

In operation **720**A, the client device disables HVAC control. For example, as previously described electronics **130** may activate heating systems, ventilation systems, air conditions systems, etc. via wire connectors **138**. In operation **720**A the client device may deactivate or otherwise disable such systems. For example, the electronic circuitry **130** may cause such systems to enter into an OFF state. In some cases, the systems may not be controlled to enter into an OFF state, but rather the electronic circuitry **130** may be temporarily disabled so as to preclude user control of the HVAC system. In such cases, prior to being disabled, the HVAC system could be controlled to enter into a particular state (e.g., an ON state or an OFF state), or may be set to maintain its state of operation existent prior to disabling of electronic circuitry **130**. For example, if the HVAC system is in an ON state prior to installing the software update, then the HVAC system may be maintained in the ON state during installation of the software update.

In operation **720**B, the software update is copied to a secondary partition. In some embodiments, the client device **520** (e.g., intelligence components **116**) may include one or more storage elements having a plurality of storage partitions. An operating system and software for controlling the client device may be installed on a primary partition from which the device operates during typical operation (e.g., during installation and subsequent operation). A secondary partition may be used to facilitate software updating as described herein. That is, while the device is operating via software installed on its primary partition, the device may copy the software update downloaded in, e.g., operation **710**, to its secondary partition.

Once the software update has been copied to the secondary partition, in operation **720**C the client device may reboot from the secondary partition. In this particular embodiment, the software update includes an operating system (which may have been updated) and may also include additional operational software (which may also or alternatively been updated). In other embodiments, the secondary partition may already have an operating system (and possibly software applications) installed thereon, and the software update may be an incremental update to the operating system and/or software applications.

In operation **720**D the client device determines whether the reboot is successful. In being successful, the operating system at the secondary partition is successfully initialized (e.g., successfully reaches steady state). If the reboot is successful, then processing may continue to operation **720**E.

In operation **720**E, the client device copies the software update to the primary partition. In some embodiments, this may include copying some or all of the contents of the secondary partition to the primary partition. In other embodiments, this may include installing the downloaded software update on the primary partition. Once the software update is installed on the primary partition, processing may continue to operation **720**F.

In operation **720**F, the client device is rebooted from the primary partition. In this particular case, that is, where the software update was copied to the primary partition, then rebooting from the primary partition will result in rebooting the client device such that the client device is operable with the software update. Processing may then continue to operation **720**G, where the client device enables HVAC control (which may be, e.g., the opposite of operation **720**A).

Returning to operation **720**D, if it is determined that reboot is unsuccessful, then processing may continue to operation **720**H. In operation **720**H the client device may output an error message to the user indicating that the software update did not successfully install. Processing may then continue to operation **720**F, where the client device reboots from the primary partition. Since in this case the software update was not copied to nor installed on the primary partition, the device reboots using the pre-update operating system and/or software application(s).

In accordance with some embodiments, even though HVAC control is may be temporarily disabled during installation of a software update the client device **520** may still be operable to communicate (e.g., receive instructions from, provide information to, etc.) with other elements of system

500. For example, while the client device 520 is copying software updates to different partitions, it may receive (and in some cases, buffer) instructions from other associated client devices (e.g., access devices) via a synchronization server 514. In at least one embodiment, however, all communications between client device 520 and other elements of system 500 may be disabled for one or more periods during installation of the software update. For example, communications may be disabled during rebooting of the device (e.g., in operations 720C and/or 720F). In such cases, the client device is effectively in a 'black out' mode of operation, where the device may not be remotely controlled and, in many cases, may not be locally (i.e., directly) controlled by a user (e.g., by a user attempting to physically manipulate or interact with the device).

It should be appreciated that the specific operations illustrated in FIGS. 8A to 8C provide particular processes for satisfying pre-download conditions, satisfying pre-install conditions, and installing software updates, according to various embodiments. Other sequences of operations may also be performed according to alternative embodiments. For example, alternative embodiments of the present invention may perform the operations outlined above in a different order. Moreover, the individual operations illustrated in FIGS. 8A to 8C may include multiple sub-operations that may be performed in various sequences as appropriate to the individual operations. Furthermore, additional operations may be added or existing operations removed depending on the particular applications. One of ordinary skill in the art would recognize and appreciate many variations, modifications, and alternatives.

FIG. 9A is a flowchart of a process for a client device to perform software updating of head units and back plates according to an embodiment. In operation 902 a client device (e.g., device 100) downloads a software update to its head unit (e.g., replaceable module 114) and, in operation 904, installs the software update to its head unit. The download and install may be performed in accordance with any of the embodiments described herein. It should be recognized, however, that the software update may include components that update software executing on the head unit as well as components that update different software executing on the back plate. Accordingly, in operation 904, the client device may install the software components that update the software executing or executable on the head unit.

In operation 906, the client device 100 determines whether the head unit 114 is connected to the back plate 112. For example, the head unit software and/or circuitry may determine whether the head unit 114 is coupled to the connection terminal 140. If it is determined that the head unit is not connected to the back plate, then processing may continue to operation 908 where the client device waits until the head unit is connected to the back plate. In some embodiments, during operation 908 the client device may communicate information to the user requesting the user to connect the head unit to the back plate. Once the head unit is connected to the back plate, processing continues to operation 910.

In operation 910, the client device determines whether the back plate needs to be updated. For example, software and/or circuitry executable in the head unit 114 may determine whether the software executing on the back plate needs to be updated in accordance with the downloaded update. If so, then processing continues to operation 912 where the software update is installed to the back plate. Otherwise, processing continues to operation 914 where the software update is not installed to the back plate.

FIG. 9B is a flowchart of a process for a client device to determine whether a back plate needs an update according to an embodiment. In some embodiments, the process may be implemented, for example, as operation 910. In other embodiments, the process may be a stand-alone process. For example, the process may be implemented at various times, such as upon connecting a head unit to a back plate, upon powering on the device, periodically, etc.

In operation 910A, the client device determines the software version of the back plate. The software version may be stored in the back plate, head unit, or other suitable storage location. In one particular embodiment, the head unit may determine the software version of the back plate by reading the stored version information.

In operation 910B, the client device determines whether the software version of the back plate is as expected. In some embodiments, the software update download may include information indicating the version of the back plate software that is the predecessor to the software update. The software running on the back plate may not be the expected version if that software is newer or older than the that indicated in the software update download. If the software version of the back plate is not as expected, then processing continues to operation 910C where it is determined that the back plate needs to be updated. In many cases, this leads to the client device updating the back plate software. Otherwise, processing continues to operation 910D where it is determined that the back plate does not need to be updated.

It should be appreciated that the specific operations illustrated in FIGS. 9A and 9B provide particular processes for performing software updates according to various embodiments. Other sequences of operations may also be performed according to alternative embodiments. For example, alternative embodiments of the present invention may perform the operations outlined above in a different order. For example, the head unit software may not be updated until the head unit is connected to the back plate. Moreover, the individual operations illustrated in FIGS. 9A and 9B may include multiple sub-operations that may be performed in various sequences as appropriate to the individual operations. Furthermore, additional operations may be added or existing operations removed depending on the particular applications. One of ordinary skill in the art would recognize and appreciate many variations, modifications, and alternatives.

FIG. 10 is a flowchart of a process 1000 for a remote server (e.g., a registration server 512) to perform software updating according to an embodiment. In operation 1002, the registration server 512 receives a device identifier for the client device 520. Processing continues to operation 1004 where the appropriate software version of the client device 520 is determined. For example, the registration server 512 may compare the received device identifier to a device identifier/software version map (that maps device identifiers to software versions) to identify the appropriate software version for the client device 520. In operation 1006, the registration server 512 determines a target location of the software update server, which may be stored at the registration server 512, included in the device identifier/software version map, or otherwise accessed by the registration server 512. The registration server 512 may then, in operation 1008, communicate the information indicating the appropriate software version to the client device, and in operation 1010 communicate the target location of the software update server to the client device. In operation 1010, the registration server 512 determines whether the software update is critical. For example, the registration server 512 may compare the software version of the update to a software version/criticality map (that maps

software versions to indicators indicating whether the software versions are critical or non-critical) to determine whether the software update is critical. The registration server **512** may then, in operation **1012**, communicate, to the client device, an indication indicating whether the software update is critical.

It should be appreciated that the specific operations illustrated in FIG. **10** provide a particular process for a remote server to perform software updating according to various embodiments. Other sequences of operations may also be performed according to alternative embodiments. For example, alternative embodiments of the present invention may perform the operations outlined above in a different order. Moreover, the individual operations illustrated in FIG. **10** may include multiple sub-operations that may be performed in various sequences as appropriate to the individual operations. Furthermore, additional operations may be added or existing operations removed depending on the particular applications. One of ordinary skill in the art would recognize and appreciate many variations, modifications, and alternatives.

FIG. **11** is a block diagram of a special-purpose computer system **1100** according to an embodiment. For example, one or more of client device **100**, elements of smart home environment **200**, remote server **264**, data processing server **307**, client device **520**, elements of remote server **510**, or other electronic components described herein may implemented as a special-purpose computer system **1100**. The above methods may be implemented by computer-program products that direct a computer system to perform the actions of the above-described methods and components. Each such computer-program product may comprise sets of instructions (codes) embodied on a computer-readable medium that directs the processor of a computer system to perform corresponding actions. The instructions may be configured to run in sequential order, or in parallel (such as under different processing threads), or in a combination thereof.

Special-purpose computer system **1100** comprises a computer **1102**, a monitor **1104** coupled to computer **1102**, one or more additional user output devices **1106** (optional) coupled to computer **1102**, one or more user input devices **1108** (e.g., keyboard, mouse, track ball, touch screen) coupled to computer **1102**, an optional communications interface **1110** coupled to computer **1102**, and a computer-program product **1112** stored in a tangible computer-readable memory in computer **1102**. Computer-program product **1112** directs system **1100** to perform the above-described methods. Computer **1102** may include one or more processors **1114** that communicate with a number of peripheral devices via a bus subsystem **1116**. These peripheral devices may include user output device(s) **1106**, user input device(s) **1108**, communications interface **1110**, and a storage subsystem, such as random access memory (RAM) **1118** and non-volatile storage drive **1120** (e.g., disk drive, optical drive, solid state drive), which are forms of tangible computer-readable memory.

Computer-program product **1112** may be stored in non-volatile storage drive **1120** or another computer-readable medium accessible to computer **1102** and loaded into memory **1118**.

Each processor **1114** may comprise a microprocessor, such as a microprocessor from Intel® or Advanced Micro Devices, Inc.®, or the like. To support computer-program product **1112**, the computer **1102** runs an operating system that handles the communications of product **1112** with the above-noted components, as well as the communications between the above-noted components in support of the computer-program product **1112**. Exemplary operating systems include Windows® or the like from Microsoft Corporation, Solaris® from Sun Microsystems, LINUX, UNIX, and the like.

User input devices **1108** include all possible types of devices and mechanisms to input information to computer system **1102**. These may include a keyboard, a keypad, a mouse, a scanner, a digital drawing pad, a touch screen incorporated into the display, audio input devices such as voice recognition systems, microphones, and other types of input devices. In various embodiments, user input devices **1108** are typically embodied as a computer mouse, a trackball, a track pad, a joystick, wireless remote, a drawing tablet, a voice command system. User input devices **1108** typically allow a user to select objects, icons, text and the like that appear on the monitor **1104** via a command such as a click of a button or the like. User output devices **1106** include all possible types of devices and mechanisms to output information from computer **1102**. These may include a display (e.g., monitor **1104**), printers, non-visual displays such as audio output devices, etc.

Communications interface **1122** provides an interface to other communication networks and devices and may serve as an interface to receive data from and transmit data to other systems, WANs and/or the Internet. Embodiments of communications interface **1122** typically include an Ethernet card, a modem (telephone, satellite, cable, ISDN), a (asynchronous) digital subscriber line (DSL) unit, a FireWire® interface, a USB® interface, a wireless network adapter, and the like. For example, communications interface **1110** may be coupled to a computer network, to a FireWire® bus, or the like. In other embodiments, communications interface **1110** may be physically integrated on the motherboard of computer **1102**, and/or may be a software program, or the like.

RAM **1118** and non-volatile storage drive **1120** are examples of tangible computer-readable media configured to store data such as computer-program product embodiments of the present invention, including executable computer code, human-readable code, or the like. Other types of tangible computer-readable media include floppy disks, removable hard disks, optical storage media such as CD-ROMs, DVDs, bar codes, semiconductor memories such as flash memories, read-only-memories (ROMs), battery-backed volatile memories, networked storage devices, and the like. RAM **1118** and non-volatile storage drive **1120** may be configured to store the basic programming and data constructs that provide the functionality of various embodiments of the present invention, as described above.

Software instruction sets that provide the functionality of the present invention may be stored in RAM **1118** and non-volatile storage drive **1120**. These instruction sets or code may be executed by the processor(s) **1114**. RAM **1118** and non-volatile storage drive **1120** may also provide a repository to store data and data structures used in accordance with the present invention. RAM **1118** and non-volatile storage drive **1280** may include a number of memories including a main random access memory (RAM) to store of instructions and data during program execution and a read-only memory (ROM) in which fixed instructions are stored. RAM **1118** and non-volatile storage drive **1120** may include a file storage subsystem providing persistent (non-volatile) storage of program and/or data files. RAM **1118** and non-volatile storage drive **1120** may also include removable storage systems, such as removable flash memory.

Bus subsystem **1116** provides a mechanism to allow the various components and subsystems of computer **1102** communicate with each other as intended. Although bus subsystem **1116** is shown schematically as a single bus, alterna-

tive embodiments of the bus subsystem may utilize multiple busses or communication paths within the computer **1102**.

For a firmware and/or software implementation, the methodologies may be implemented with modules (e.g., procedures, functions, and so on) that perform the functions described herein. Any machine-readable medium tangibly embodying instructions may be used in implementing the methodologies described herein. For example, software codes may be stored in a memory. Memory may be implemented within the processor or external to the processor. As used herein the term "memory" refers to any type of long term, short term, volatile, nonvolatile, or other storage medium and is not to be limited to any particular type of memory or number of memories, or type of media upon which memory is stored.

Moreover, as disclosed herein, the term "storage medium" may represent one or more memories for storing data, including read only memory (ROM), random access memory (RAM), magnetic RAM, core memory, magnetic disk storage mediums, optical storage mediums, flash memory devices and/or other machine readable mediums for storing information. The term "machine-readable medium" includes, but is not limited to portable or fixed storage devices, optical storage devices, wireless channels, and/or various other storage mediums capable of storing that contain or carry instruction(s) and/or data.

Specific details are given in the above description to provide a thorough understanding of the embodiments. However, it is understood that the embodiments may be practiced without these specific details. For example, circuits may be shown in block diagrams in order not to obscure the embodiments in unnecessary detail. In other instances, well-known circuits, processes, algorithms, structures, and techniques may be shown without unnecessary detail in order to avoid obscuring the embodiments.

Implementation of the techniques, blocks, steps and means described above may be done in various ways. For example, these techniques, blocks, steps and means may be implemented in hardware, software, or a combination thereof. For a hardware implementation, the processing units may be implemented within one or more application specific integrated circuits (ASICs), digital signal processors (DSPs), digital signal processing devices (DSPDs), programmable logic devices (PLDs), field programmable gate arrays (FPGAs), processors, controllers, micro-controllers, microprocessors, other electronic units designed to perform the functions described above, and/or a combination thereof.

Also, it is noted that the embodiments may be described as a process which is depicted as a flowchart, a flow diagram, a data flow diagram, a structure diagram, or a block diagram. Although a flowchart may describe the operations as a sequential process, many of the operations can be performed in parallel or concurrently. In addition, the order of the operations may be re-arranged. A process is terminated when its operations are completed, but could have additional steps not included in the figure. A process may correspond to a method, a function, a procedure, a subroutine, a subprogram, etc. When a process corresponds to a function, its termination corresponds to a return of the function to the calling function or the main function.

Furthermore, embodiments may be implemented by hardware, software, scripting languages, firmware, middleware, microcode, hardware description languages, and/or any combination thereof. When implemented in software, firmware, middleware, scripting language, and/or microcode, the program code or code segments to perform the necessary tasks may be stored in a machine readable medium such as a storage medium. A code segment or machine-executable instruction may represent a procedure, a function, a subprogram, a program, a routine, a subroutine, a module, a software package, a script, a class, or any combination of instructions, data structures, and/or program statements. A code segment may be coupled to another code segment or a hardware circuit by passing and/or receiving information, data, arguments, parameters, and/or memory contents. Information, arguments, parameters, data, etc. may be passed, forwarded, or transmitted via any suitable means including memory sharing, message passing, token passing, network transmission, etc.

The subject matter of this patent specification relates to the subject matter of the following commonly assigned applications, each of which is incorporated by reference herein: U.S. Ser. No. 13/269,501 filed Oct. 7, 2011; and U.S. Ser. No. 13/466,815 filed May 8, 2012.

While the principles of the present teachings have been described above in connection with specific apparatuses and methods, it is to be clearly understood that this description is made only by way of example and not as limitation on the scope of the present teachings.

What is claimed is:

1. An intelligent network-connected thermostat for controlling an operation of an HVAC system in a smart home environment, the thermostat comprising:

a communications component for communicating with at least one server that is located remotely from the thermostat;

HVAC control circuitry operable to actuate one or more elements of the HVAC system;

a storage element for storing computer software operable to control one or more functions of the thermostat; and

a processor operable to cause the thermostat to perform operations including:

receiving a criticality indicator indicating whether a software update to the computer software stored in the storage element is critical or not;

downloading the software update from a software update server via the communications component;

determining whether an initial installation of the thermostat is currently taking place;

installing the software update prior to a completion of the initial installation of the thermostat if the criticality indicator indicates that the software update is critical; and

delaying, if the criticality indicator indicates that the software update is not critical, installation of the software update until after the initial installation of the thermostat in the physical structure is complete.

2. The thermostat of claim **1**, wherein the software update is critical when installation of the software update would interrupt the installation of the thermostat.

3. The thermostat of claim **1**, wherein the criticality indicator is received from a registration server separate from the software update server.

4. The thermostat of claim **1**, wherein the processor is further operable to cause the thermostat to satisfy pre-download conditions prior to downloading the software update.

5. The thermostat of claim **4**, wherein the pre-download conditions include:

ensuring the thermostat is in an awake mode; and

ensuring the thermostat has sufficient battery charge if a power connection is unavailable.

6. The thermostat of claim **1**, wherein the processor is further operable to cause the thermostat to satisfy pre-install conditions prior to installing the software update.

7. The thermostat of claim 6, wherein the pre-install conditions include:
ensuring the thermostat is in an awake mode;
ensuring the thermostat has a sufficient battery charge if a power connection is unavailable;
ensuring a replaceable module of the thermostat is connected to a docking station of the thermostat;
ensuring a user interface of the thermostat is not displaying information; and
ensuring the HVAC system is inactive.

8. A computer-implemented method, comprising:
receiving a criticality indicator at a thermostat, wherein the criticality indicator indicates whether a software update to computer software stored in a storage element of the thermostat is critical or not, and wherein the thermostat is coupled to an HVAC system;
receiving the software update at the thermostat;
determining whether an initial installation of the thermostat is currently taking place;
determining whether the software update to the computer software stored in the storage element of the thermostat is critical;
installing the software update when the criticality indicator indicates that the software update is critical, wherein the software update is installed before the initial installation of the thermostat is completed; and
delaying installation of the software update when the criticality indicator indicates that the software update is not critical, wherein the installation of the software update is delayed until after the initial installation of the thermostat is completed.

9. The computer-implemented method of claim 8, further comprising:
determining whether HVAC control circuitry included in the thermostat has actuated one or more elements of the HVAC system to be in an active state; and
delaying installation of the software update when one or more elements of the HVAC system are in an active state, wherein installation is delayed until the one or more elements of the HVAC system are in an inactive state.

10. The computer-implemented method of claim 8, further comprising:
disabling control of one or more elements of the HVAC system;
installing the software update while control of the one or more elements of the HVAC system is disabled; and
enabling control of the one or more elements of the HVAC system after installing the software update.

11. The computer-implemented method of claim 10, wherein:
disabling control of one or more elements of the HVAC system includes disabling at least a portion of HVAC control circuitry included in the thermostat; and
enabling control of the one or more elements of the HVAC system includes enabling at least a portion of the HVAC control circuitry included in the thermostat.

12. The computer-implemented method of claim 8, further comprising:
determining whether one or more pre-download conditions are satisfied prior to receiving the software update.

13. The computer-implemented method of claim 12, wherein the pre-download conditions include:
the thermostat is in an awake mode; and
the thermostat has a sufficient battery charge if a power connection is unavailable.

14. The computer-implemented method of claim 8, further comprising:
determining whether one or more pre-install conditions are satisfied prior to installing the software update.

15. The computer-implemented method of claim 14, wherein the pre-install conditions include:
the thermostat is in an awake mode;
the thermostat has a sufficient battery charge if a power connection is unavailable;
a replaceable module of the thermostat is connected to a docking station of the thermostat;
a user interface of the thermostat is not displaying information; and
the HVAC system is inactive.

16. A tangible non-transitory computer-readable storage medium including instructions that, when executed by a computer processor, cause the computer processor to perform operations comprising:
receiving a criticality indicator at a thermostat, wherein the criticality indicator indicates whether a software update to computer software stored in a storage element of the thermostat is critical or not, and wherein the thermostat is coupled to an HVAC system;
receiving the software update at the thermostat;
determining whether an initial installation of the thermostat is currently taking place;
determining whether the software update to the computer software stored in the storage element of the thermostat is critical;
installing the software update when the criticality indicator indicates that the software update is critical, wherein the software update is installed before the initial installation of the thermostat is completed; and
delaying installation of the software update when the criticality indicator indicates that the software update is not critical, wherein the installation of the software update is delayed until after the initial installation of the thermostat is completed.

17. The storage medium of claim 16, wherein the software update is critical when installation of the software update would interrupt installation of the thermostat.

18. The storage medium of claim 16, wherein the criticality indicator is received from a registration server separate from a software update server that provided the software update to the thermostat.

19. The storage medium of claim 16, further comprising instructions that, when executed by the computer processor, cause the computer processor to perform operations comprising:
determining whether HVAC control circuitry included in the thermostat has actuated one or more elements of the HVAC system to be in an active state; and
delaying installation of the software update when one or more elements of the HVAC system are in an active state, wherein installation is delayed until the one or more elements of the HVAC system are in an inactive state.

20. The storage medium of claim 16, further comprising instructions that, when executed by the computer processor, cause the computer processor to perform operations comprising:
determining whether the thermostat is in an awake mode; and
delaying installation of the software update until the thermostat is in a non-awake mode.

21. The storage medium of claim 16, further comprising instructions that, when executed by the computer processor, cause the computer processor to perform operations comprising:

determining whether the thermostat has a battery charge sufficient to install the software update; and

delaying installation of the software update until the thermostat has a battery charge sufficient to install the software update.

22. The storage medium of claim **16**, further comprising instructions that, when executed by the computer processor, cause the computer processor to perform operations comprising:

determining whether a replaceable module of the thermostat is connected to a docking station of the thermostat; and

delaying installation of the software update until the replaceable module is connected to the docking station.

23. The storage medium of claim **16**, further comprising instructions that, when executed by the computer processor, cause the computer processor to perform operations comprising:

determining whether a display of the thermostat is active; and

delaying installation of the software update until the display of the thermostat is inactive.

24. A computer-implemented system, comprising:

one or more processors; and

one or more non-transitory computer-readable storage mediums containing instructions configured to cause the one or more processors to perform operations including:

receiving a criticality indicator at a thermostat indicating whether a software update to computer software stored in a storage element is critical or not;

receiving the software update from a remote server via a communications component;

determining whether an initial installation of the thermostat is currently taking place;

determining whether the software update to the computer software stored in the storage element is critical;

installing the software update when the criticality indicator indicates that the software update is critical, wherein the software update is installed before the initial installation of the thermostat is completed; and

delaying installation of the software update when the criticality indicator indicates that the software update is not critical, wherein the installation of the software update is delayed until after the initial installation of the thermostat is completed.

25. The system of claim **24**, further comprising instructions configured to cause the one or more processors to perform operations including:

disabling control of one or more elements of an HVAC system coupled to the thermostat;

installing the software update while control of the one or more elements of the HVAC system is disabled; and

enabling control of the one or more elements of the HVAC system after installing the software update.

26. The system of claim **24**, wherein the storage element includes a primary partition and a secondary partition, and software operable to control one or more functions of the thermostat is provided on the primary partition.

27. The system of claim **26**, further comprising instructions configured to cause the one or more processors to perform operations including:

copying the software update to the secondary partition;

rebooting the thermostat from the secondary partition; and

determining whether the reboot is successful.

28. The system of claim **27**, further comprising instructions configured to cause the one or more processors to perform operations including:

determining that the reboot is successful;

copying the software update to the primary partition; and

rebooting the thermostat from the primary partition such that the thermostat is rebooted to incorporate the software update.

29. The system of claim **27**, further comprising instructions configured to cause the one or more processors to perform operations including:

determining that the reboot is unsuccessful; and

rebooting the thermostat from the primary partition such that the thermostat is rebooted without incorporating the software update.

30. The system of claim **27**, further comprising instructions configured to cause the one or more processors to perform operations including:

determining that the reboot is unsuccessful; and

communicating an error message to the user indicating that installation of the software update was unsuccessful.

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